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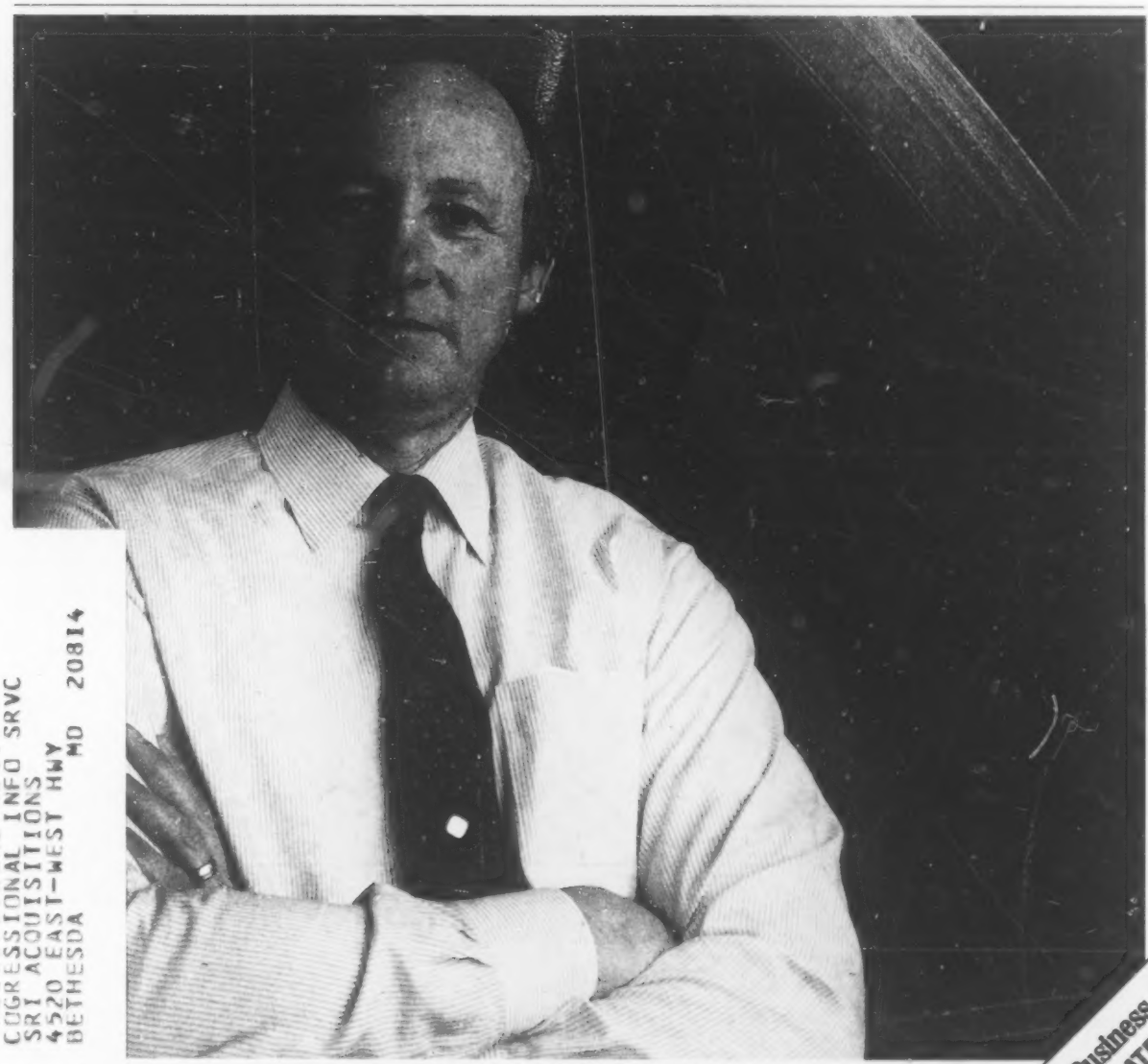
Electronic Business®

U.S. chip makers may want to feed Asia's dragons PAGE 26

Workstation vendors try third-party sales channels PAGE 64



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Electronic Business

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THE BUSINESS MAGAZINE FOR MANAGEMENT IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES

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Cover Photo/Dave Bradley

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VBPA ABP

Printed wiring boards: The missing component

PW boards are important electronic components. Will Taiwan produce more of them in 1988?

Fortunately for the U.S. electronics industry in general — and for this editor in particular, who needs dependable statistics to evaluate the health of the industry and detect trends — the U.S. Department of Commerce includes semiconductors under the Standard Industrial Classification (SIC) 367. This category covers electronic components; and semiconductors represent almost half of this country's electronic components market. Unfortunately, however, SIC 367 does not include printed wiring boards. The reason is that half of the boards' production in the United States is captive. Since AT&T and IBM are the major producers of boards, it is simpler for the government to consider the value of the PWBs these companies produce as part of the value of AT&T's communications equipment and IBM's computers.

There are many other problems with SIC 367, but the omission of PWBs, while perhaps understandable, is nonetheless lamentable because they are the major elements that support and interconnect most of the other components in electronic and computer equipment. In value, PWBs last year represented almost 20% of the market for electronic components in the United States.

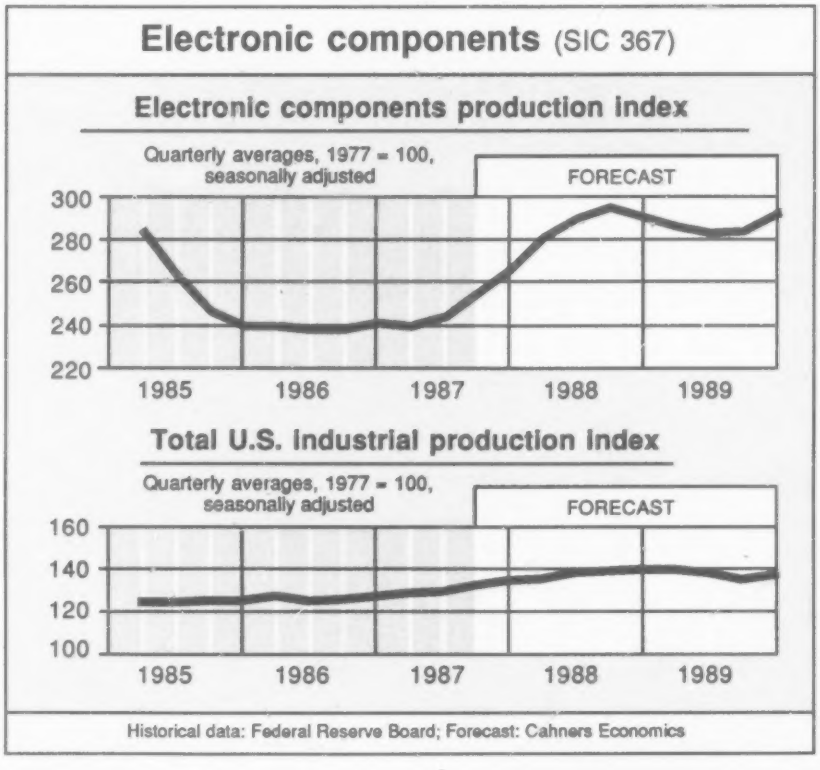
Moreover, the boards' market is far more volatile than the market for other components, even for semiconductors. The reason is that boards change not only with developments in board-making technology, but also with the changes in the components they carry.

According to The Institute for Interconnecting and Packaging Electronic Circuits, the U.S. market for rigid PWBs (single sided, double sided, and multilayer) was $4.4 billion last year, up 20% over 1986, an increase commensurate with that of the market for semiconductors. IPC's executive director Ray Pritchard attributes the gain to increasing demand, particularly from computer manufacturers, but also from firming up of prices.

However, last year, while the United States and Japan represented 32% and 39%, respectively, of the worldwide semiconductor market, they each accounted for 29% of the printed wiring boards market. The reason is that Hong Kong, Singapore and Taiwan are important producers and consumers of PWBs. Pritchard puts last year's Taiwan market for rigid boards at $0.5 billion, but notes that Taiwan is a net exporter of boards. "Many come to the U.S. embedded in personal computers," he explains. Board expert Dr. Hayao Nakahara, of Kollmorgen Corp.'s subsidiary PCK Technology, says that some of the board production that migrated in recent years from the United States to Taiwan may return here this year because the strengthening New Taiwan dollar is making their boards more expensive. However, Pritchard sees only 5% growth for the U.S. board market this year. "I'm nervous for 1988," he says.

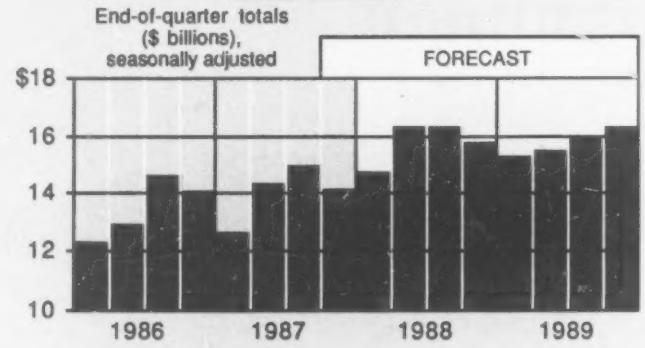
Compared with the components that SIC 367 tracks, this would be a reversal from last year. Industrial production of SIC 367 increased only 4.6% in 1987, and Cahners' senior economist Elizabeth Baatz forecasts more than 15% growth for this year. While most of this increase will be fueled by semiconductor production, Baatz's forecast, as well as those by many PWB makers, makes Pritchard's nervous estimate look very conservative.

ALBERTO SOCOLOVSKY

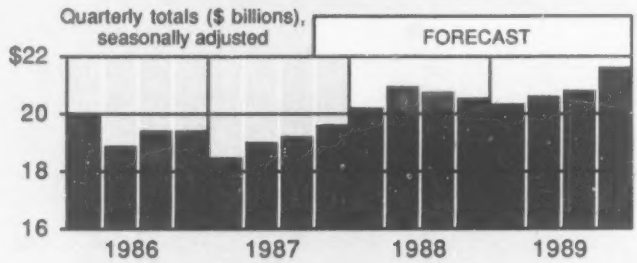


Office and computing equipment (SIC 357)

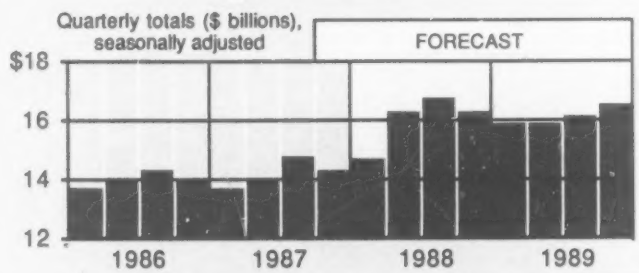
New orders



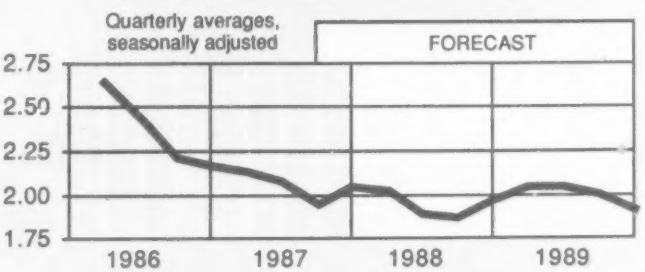
Unfilled orders



Shipments



Inventory-to-shipment ratio



Historical data: U.S. Commerce Department; Forecast: Cahners Economics

New orders

New orders for computers and office machinery were estimated at $14.1 billion on a seasonally adjusted basis for the fourth quarter of 1987, just 0.7% above the same quarter in 1986. The fourth quarter estimate brought total new orders for 1987 to $56 billion, or 4% higher than in 1986. Orders declined from $5.05 billion in October to $4.12 billion in November (-18.5%), deflating the fast growth in new orders and reducing the total for the final quarter and the year. This setback will be reversed as businesses regain confidence that the current expansion will stick. New orders are forecast to grow 12% this year, before tapering off during 1989.

Unfilled orders

In February of 1987, the value of unfilled orders hit a low of $18.5 billion after being as high as $24 billion in March of 1985. In the final quarter of 1987, unfilled orders hovered around the $19.3 billion mark, reflecting the buildup of backlogs that resulted from the earlier growth in new orders. By the end of 1988, backlogs will have grown by about 7.6% to tally $20.5 billion, a more modest growth than the 16% recorded in 1985.

Shipments

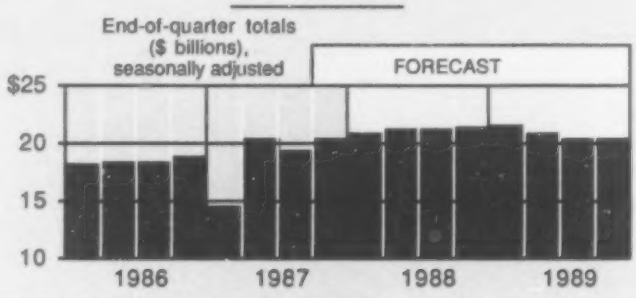
Shipments growth bottomed out at the end of 1986 and has been on a comeback since then. The recovery has been slow, however, and not without setbacks. First and second quarter shipments for 1987 were below the comparable periods in 1986. By the third quarter, growth in shipments picked up and stood 3.9% higher than the year-ago quarter. However, the October to November decline of 13.2% from $4.9 billion to $4.3 billion hurt, and brought down fourth quarter and year-end performance. The total estimate for 1987 of $56.4 billion is just 1% greater than the year before. This year, shipments are expected to be up about 13%.

Inventory-to-shipment ratio

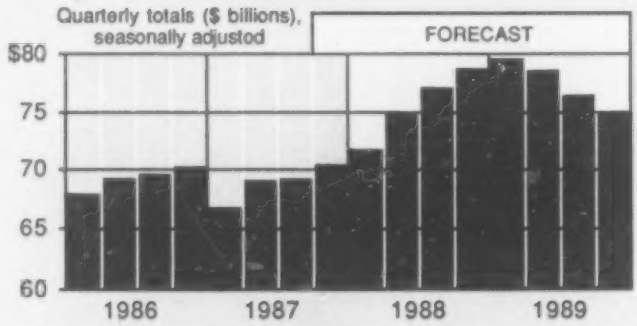
Manufacturers have been keeping a watchful eye on inventory levels. From a peak month-end figure of $13.6 billion at the beginning of 1985, inventory value dropped to about $9.7 billion by year-end 1987. The depletion and control of inventory coupled with the modest rise in shipments caused the I/S ratio to plummet from 2.65 to 2.04 over the same time period. Inventory levels will creep up in 1988, but stay well below the peak values hit in 1985. Given the better inventory management and the rise in shipments, I/S ratios will continue to head down to about 1.88 before turning upward again to end the year at around 1.97.

Communication equipment (SIC 366)

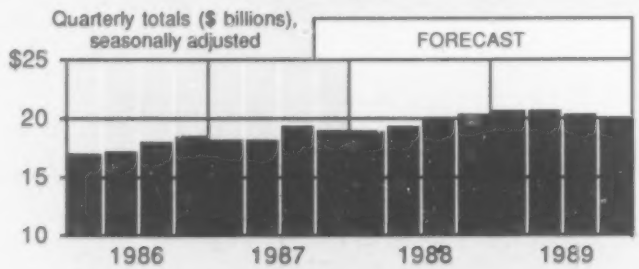
New orders



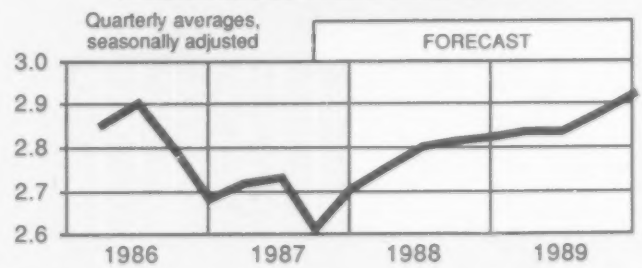
Unfilled orders



Shipments



Inventory-to-shipment ratio



Historical data: U.S. Commerce Department; Forecast: Cahners Economics

New orders

Communication equipment makers saw an erratic orders pattern in the second half of 1987. Orders fell 5.2% in the third quarter but rose 5.3% in the fourth quarter. By year-end, orders totaled just over $74 billion, a 1.6% advance over 1986 orders. About 50% of this market is dependent on military spending, so the projected slowdown in federal military purchases will keep a lid on new orders in 1988. Cahners Economics expects orders to grow 13.4% in 1988, but then fall sharply to a 2% decline in 1989. The commercial markets must pick up the defense slack in order to see a 13% gain this year.

Unfilled orders

Unfilled orders for communication equipment hit $70.2 billion last November, the highest level of backlogs ever. However, the Commerce Department only measures orders in current dollars. That means the effect of inflation is not taken into account. Most likely, after price changes, backlogs peaked in late 1986 or early 1987. The rate at which communication equipment backlogs have been growing has been on a downward path since the fall of 1985. In fact, the backlog's growth rate is at its lowest level since 1974. Orders will feed into larger backlogs in 1988, but growth is not expected to last into 1989.

Shipments

After a phenomenal 6.1% surge in the third quarter of 1987, shipments of communication equipment dropped an estimated 1.4% in the fourth quarter. That puts annual shipments for last year at $73.6 billion, a 5.8% gain over 1986. Cahners Economics forecasts another 5.6% annual gain in 1988, followed by a 3.2% rise in 1989. 1987 marked a turnaround for this industry: For the first time in six years, shipments of communication equipment to commercial buyers outpaced shipments to military facilities. Last year, about 45% of all communication equipment was shipped for military needs like radar, sonar and electronic warfare systems.

Inventory-to-shipment ratio

After falling to 2.58 in September, its lowest level in nine years, the I/S ratio rose to 2.76 in November. Still, the I/S ratio remains relatively low. In 1984, the ratio frequently hit the 3.0 mark. With the forecast for shipments in 1988 and 1989 at only 3% to 5% growth, the I/S ratio should not hit its 3.0 mark in the next year. If it does so, then excess inventory could cause production to take a cutback.

FAR EAST

Chip and equipment makers: Want to feed the dragons?

By 1992, Singapore, Taiwan, Korea and Hong Kong will consume as many chips as Europe

As one of today's most dynamic economic regions, Asia (with emphasis here on the four little dragons, exclusive of Japan) is expected to catch both the United States and Japan in the next few years in the field of information products, according to an increasing number of business executives and experts in the industry. The four little dragons, or tigers as they are sometimes called, are: South Korea, Hong Kong, Singapore and Taiwan.

Already, these four economies have demonstrated their potential in developing the semiconductor industry — a potential that promises much for U.S. equipment vendors. According to Dataquest Inc., the San Jose-based market research firm, the rest of the world (ROW) semiconductor market (mostly the Asian Pacific region, and mainly denoting the four little fire-breathers) will comprise 17% of the world market by 1992, roughly matching Europe's share.

Adds C.D. Tam, vice president and general manager of Motorola Inc.'s Asian/Pacific semiconductor products region: "Looking at the established infrastructure, underlying strength, culture and ethics, and the continued transfer of electronic equipment manufacturing to the Asian Pacific region, our conclusion is that semiconductor consumption (a measure of electronic and equipment production) will catch up with Europe before 1993. This conclusion is important as it portends the gravitational shift of global electronics."

In 1987, ROW consumed an estimated $4.9 billion worth of semiconductors. That conceals some strong growth figures: Dataquest reports that ROW chip consumption jumped 55.6% in 1986 and 38.1% in 1987, compared with 6.5% and 12.7% respectively in North America, 44.9% and 14% in Japan, and 17.2% and 10% in Europe. As a result, the ROW share of worldwide semiconductor consumption rose to 11.4% in 1987, up from 1986's 9.5%. In 1988, the rate is expected to advance further, to 12%, compared with Europe's 16.7%.

Asia's four dragons: Korea, Singapore, Hong Kong and Taiwan

Armen Kojoyian

Additionally, the region is becoming increasingly self-reliant in chip making, producing in 1986, $1,292 million worth in South Korea; $689 million worth in Taiwan; and chips worth $169 million in Hong Kong and $1,177 million in Singapore.

The vigorous development of ROW's information product market represents substantial business opportunities for both materials and equipment suppliers. Despite the remarkable growth of their production capacity, ROW economies still rely very much on outside IC suppliers. Equipment sales for the electronics industries in Taiwan and South Korea are 2.5 times higher than the world average, notes Robert Tsao, president of United Microelectronics Corporation (UMC) of Taiwan. For instance, demand for IC production and testing equipment by IC makers, and for workstations by IC design houses, is growing significantly.

In view of these prospects, LTX Corp., which produces digital VLSI test systems and networks, has established sales and support centers for its equipment in Singapore, Taiwan and Japan. "Some of these centers are not economically justified, if based on short-term business alone, but are a way of saying to our current and potential Asian customers that we are here [in Asia] for the long term," remarks James Healy, senior vice president at LTX.

In 1987, four leading IC makers in the region all registered remarkable sales growth: Goldstar Co., with $85 million in sales and a 44% growth rate; Hyundai Electronics Industries Company Ltd.,

$35 million, 75%; Samsung Group, $250 million, 47%; and UMC, $100 million, 42%. UMC just broke ground for its new VLSI plant, which will require an investment of $200 million for a monthly capacity of 30,000 6-inch wafers.

IC design capability has also been developing rapidly in recent years. UMC, for instance, started its in-house design in 1984 and has turned out 50 to 60 new products annually ever since. In fact, in the first half of 1987 it brought out 100 new products. This is the major reason for the handsome profit being enjoyed by the firm. In 1987, the company reaped $20 million in profits, against revenue of $100 million. IC design houses began emerging in Taiwan in 1980 and in 1987 their number topped 30.

In the most advanced area of very large-scale integrated circuits, Asian production will catch up with that of the United States and Japan in five years, according to Tom Wang, an associate director for Dataquest.

Wang points out that there are four major factors which will help Asian economies achieve the goal. First, is the growing local demand. Second, is government support, as the governments of the four little dragons all have special institutions to carry out VLSI research.

The third factor is that leading IC makers in the region are spending heavily on R&D projects. The corporate capital and R&D spending of Samsung topped $220 million in 1985 and $127 million in 1986; Goldstar expended $107 million and $90 million in the respective two years; and Hyundai unloaded $141 million and $31 million for R&D in the two years.

And finally, the substantial market potential, along with the availability of very qualified but inexpensive engineers, has induced a growing number of international IC makers to seek joint ventures with their counterparts in the region. In South Korea, Samsung has formed a strategic alliance with Micron Technology for the production of 64 kilobit and 256K DRAMs memory chips, and with Intel Corp. for 8-bit microprocessor units, EPROMs, and 256K DRAMs. Also, Goldstar is working with Advanced Micro Devices Inc. on 64K and 256K DRAMs, and with LSI Logic Corp. on CMOS gate arrays. Meanwhile, Hyundai has link-ups with ICT on EPROMs; with Vitelic

Semiconductor usage in the rest of the world — mostly in the Asian Pacific region — is growing much faster than anywhere else...

Semiconductor consumption
(Percentage change from previous year)

	1986	1987	1988
North America	+6.5%	+12.7%	+23.4%
Japan ($)	+44.9%	+14.0%	+19.0%
Japan (yen)	+1.9%	+9.0%	+19.9%
Europe	+17.2%	+10.0%	+19.9%
Rest of world	+55.6%	+38.1%	+28.2%
Worldwide	+25.6%	+15.1%	+21.6%

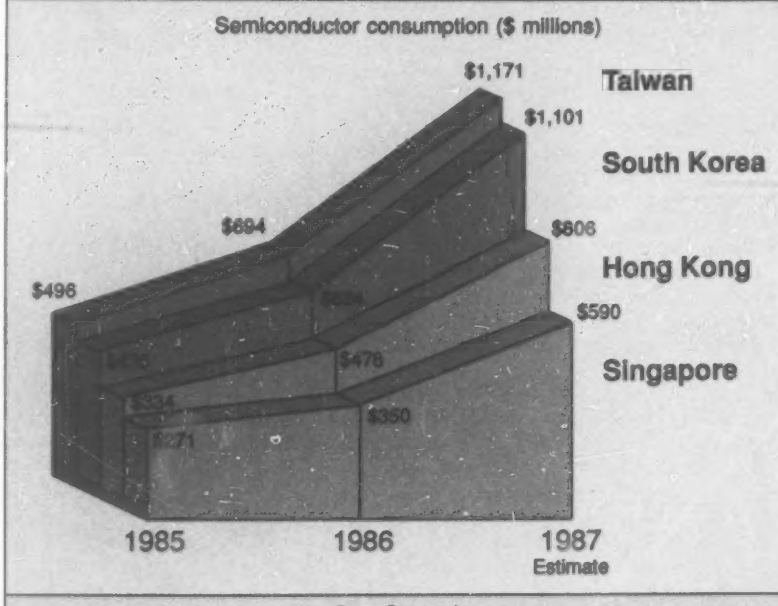
...so that it will match Europe's semiconductor consumption by 1992

Semiconductor consumption ($ billions)

	1987	1988	1992
Japan	$14.5	$17.4	$27.5
United States	$12.5	$14.2	$20.2
Europe	$6.8	$7.5	$11.9
Rest of world	$4.9	$6.3	$11.8

Source: Dataquest Inc.

Asia's four dragons are hungry for chips...



Source: Dataquest Inc.

Do yourself a service
Let ELECTRONIC BUSINESS readers know about your services

Next August 15, ELECTRONIC BUSINESS will publish its annual directory of Services for the Electronics Industry. If your company can help other electronics and computer companies complete a project on time, save costs, reduce risk, get to market faster and safer, increase efficiency, improve quality, or any other pertinent electronics service, the name of your company or division, and the type of service it provides for our readers, belong in the pages of the ELECTRONIC BUSINESS directory.

Example of services that will be listed:

Design: product design, circuit design, custom ICs, design centers, software development, package and packaging design, thermal design, documentation.

Manufacturing: contract manufacturing, printed circuit design and fabrication, mass lamination, purchasing services, kitting services, value added services, cabling, connector assembly, quality assurance service, just-in-time services, component procurement services, production software services, electrostatic discharge protection services.

Test: electrical test services, environmental testing, failure analysis, instrument rental services, test software development, production testing.

IC Foundry: silicon, CMOS, custom processes, gallium arsenide.

IC Assembly: die attachment, wirebonding, packaging, marking, sorting.

Distribution: services by and for industrial distributors, distribution channels, dealers, packaging for distribution and retailing, point of sale services.

Training: quality training, statistical production control, JIT training, purchasing, negotiating, management training.

Management: product strategy, global strategy, international operations, management consulting, temporary additions to management team.

Marketing and Sales: strategy, market research, product strategy, product position, sales representation, product promotion, export promotion, advertising, public relations.

Financial: leasing, banking, insurance, venture capital, mergers and acquisitions.

Transportation: freight forwarding, air cargo, customized packaging.

How to submit your listing:

- Name, address and telephone number of company or division that performs the service. If available, add telex and fax numbers.
- Type of service: Please be specific. (If you enter in more than one category, such as design and manufacturing, please list separately.)
- Name of managers(s) responsible for services for electronics and computer companies. Include direct telephone number, if available.
- Current volume of sales of this type of service to electronics and computer companies.
- Number of employees at this company or division, involved in this type of service.
- Specialized equipment, knowledge, and/or capabilities, which qualify your operation to perform this service. (Please list or describe in 50 words or less.)
- Name of at least one client among electronics and/or computer companies.

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Corp. for 64K, 256K and 1Mb DRAMs; and with Texas Instruments Inc. for 256K DRAMs. At the same time, Daewoo Electronics Co. Ltd. is working with Zymos Corp. on standard cells. In Taiwan, UMC cooperates with Synertek Inc. for producing microprocessors. Taiwan's governmental VLSI research institute also has joint projects with Vitelic for 256K DRAMs.

High-end chips too

In fact, the attraction of the market potential and abundant engineering talent have induced a growing number of foreign manufacturers to establish their manufacturing bases in the region, not for low-end, but for high-tech products. SGS Semiconductor (Pte) Ltd., an Asian subsidiary of the Italian IC maker, is a case in point. One major factor which induced SGS to start its assembly factory in Singapore in 1969 was the low labor cost in the region. But over the years, the

In VLSI circuits, Asian production will catch up with that of the U.S. and Japan in five years

picture has changed substantially. Through a continuous program of training and investment, the company has seen this plant rise from manufacturing epoxy transistors at 1 million to 3 million per month to making complex ICs at a rate of over 30 million per month. The plant now manufactures over 500 product lines in a "clean environment." The firm's sales topped $100 million in 1987, compared with $10.5 million back in 1980.

In addition to this successful partnership, SGS has established a similar plant in Malaysia. It has made a great effort to train local engineers and managers, transferring both management skills and know-how. Comments Antony Watts, director of strategic planning for the company: "We believe that in the future, fewer and fewer corporations will make up the semiconductor industry, and those large enough to stay in the line will form closer cooperative links to users."

PHILIP LIU

Liu is a business writer based in Taiwan

TRADE

U.S.-Canada trade pact: Good news for electronics

There's more to it than easier cross-border sales of PBXs, modems and switches. It could help ease future patent tiffs

For the electronics and telecommunications industries, the pending U.S.-Canada free trade agreement is a "win-win" kind of a deal.

That's the word from industry executives on both sides of the border and from U.S. government officials who negotiated the historic free trade pact between the world's two largest bilateral trading partners.

The agreement, which still must be approved by the Canadian Parliament and the U.S. Congress, would phase out all bilateral tariffs over 10 years and establish a controversial dispute settlement mechanism to resolve trade conflicts between the two nations. It would take effect Jan. 1, 1989.

For the telecommunications industry, there's a little-noticed kicker added to the free trade pact, literally at the 11th hour: an agreement to speed up the elimination of tariffs on both sides of the border on such key products as switches, PBXs, telephone handsets, modems and parts. "On the bulk of these items, the phaseout will be immediate," discloses one mid-level U.S. official closely involved in the telecommunications negotiations.

What this means is that there will be immediate free trade on a wide range of telecommunications products starting next year, assuming that the Canadian Parliament and the U.S. Congress approve the overall trade pact. Under the original agreement, initialled by negotiators on Oct. 3, 1987, there was a gradual five-year tariff phaseout on most of these products. Especially important will be the immediate dropping of the current 17.5% tariff in Canada on telephone sets and PBX switches.

"The removal of tariffs on telecommunications was accelerated in the final agreement," confirms Peter Murphy, who headed the U.S. negotiating team at the Office of the United States Trade Representative, the executive branch trade agency. "Some were moved from a 10-year phaseout down to five years, but most were moved from five years to zero... We think this should satisfy the industry."

Indeed, the telecommunications sector — and the electronics industry in general — seems pleased by the prospect of the pending new trade pact. "The pact is sure to help our industry expand markets, reduce costs and improve our products," says Oliver Smoot, executive vice president of the Computer and Business Equipment Manufacturers Association. CBEMA and AT&T were prime movers in lobbying to remove the 17.5% tariff in Canada on telecom equipment coming from the United States.

PRESIDENT REAGAN and Canadian Premier Brian Mulroney signed the free trade pact in January. Reagan noted that it will save U.S. consumers "hundreds of millions of dollars"

Reuters/Bettmann Newsphotos

Historic achievement

When President Reagan and Canadian Prime Minister Brian Mulroney signed the free trade agreement in early January, both hailed the pact as an historic achievement. Reagan stressed that the agreement will benefit consumers on both sides of the border, noting that it will save U.S. consumers "hundreds of millions of dollars while also improving our export opportunities."

Mulroney, for his part, asserted that the signing sends "a powerful signal toward liberalized trade around the world," an assertion that highlights a significant aspect of the free trade pact. It is likely to provide some important spadework for progress on the new round of multilateral trade negotiations — the Uruguay Round — under the auspices of the General Agreement on Tariffs and Trade (GATT). Some major problems for both countries which have an impact directly on the electronics industry — disputes over copyrights and patents and the whole area of intellectual property — were left for multilateral resolution within the new GATT talks.

But first there is the question of approval by the legislative bodies in both countries, a procedure which everyone acknowledges will take some time. In the United States the

key players in trade policymaking on Capitol Hill, notably Sen. Lloyd Bensten (D-Texas), chairman of the Senate Finance Committee, and Rep. Daniel Rostenkowski (D-Ill.), of the Ways and Means Committee, have made it clear that they will hold up consideration of the landmark free trade agreement until June 1 to give Congress time to first consider the wide-ranging omnibus trade legislation known as HR 3 in the House.

Administration officials, however, want fast Congressional action on the free trade agreement. Industry insiders in Washington think that Congress will prevail on this point, noting that extensive committee work on the omnibus trade bill is already well underway and that this will be handled ahead of a congressional review of the free trade deal. In the end, most analysts think Congress will okay the pact.

It's important to note that Congress will have to act quickly, something that could be difficult given the relatively scarce number of real working days scheduled in this election year and a full plate on other issues. Once the implementing legislation on the free trade agreement is introduced in Congress, both the House and the Senate will have 90 legislative days to finish their review and then cast what essentially amounts to an "up or down" vote approval.

It's expected that the Canadian Parliament will act on the new agreement well ahead of the Congress, possibly as early as this month. Opponents of Mulroney, expecially Liberal leader John Turner and New Democratic Party leader Ed Broadbent, are expected to mount an all-out attack on the free trade accord. "It's not a trade deal," says Turner. "It should be called the Sale of Canada Act."

Incensing the politicos

There are many aspects of the agreement which incense opposition leaders in Canada. But a major point of contention in Canada is that the Canadians were unable to win the outright exemption they sought from U.S. trade laws, most notably the anti dumping and countervailing duty actions which have been filed in fairly significant numbers against a range of Canadian products in recent years. Turner and others argue that the deal is thus "flawed" from the Canadian vantage point because it fails to provide secure access to the U.S. market.

Trying to guess the outcome in Parliament is probably even more difficult than predicting what Congress will do, but most trade analysts do think that Mulroney will be able to carry the day and push the trade agreement through Parliament.

One aspect of the pending free trade agreement that is sure to cause plenty of debate in both nations is the dispute settlement mechanism. As described by one U.S. official, who asked not to be identified, all final dumping and countervailing or subsidy cases would go to a binational panel of lawyers who would "adjudicate" the case on the basis of existing law in the importing country.

One study estimates that the U.S.-Canada free trade agreement will increase the U.S. GNP by 1% and Canada's GNP by 7%

"Either side can take a case to this panel," this official says. "Private parties can bring cases, too." There would be five members on the dispute settlement panel, two from each country and a fifth who is "mutually agreed upon." Panel decisions would be binding.

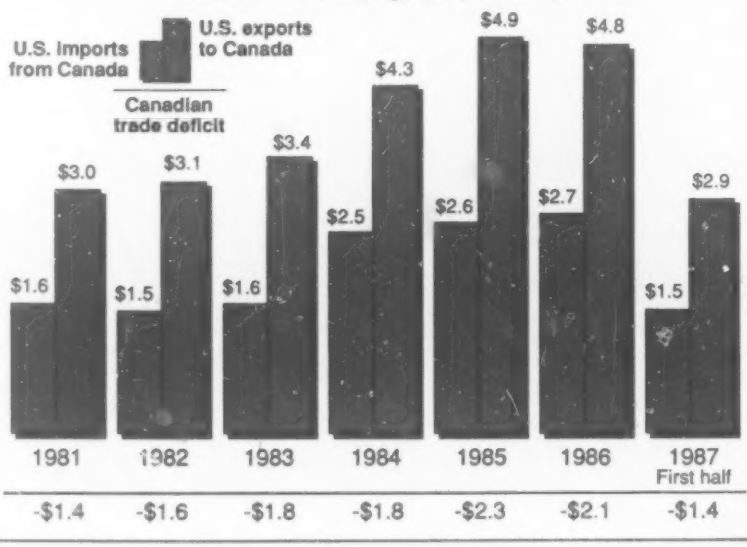
Another wrinkle which might be worth keeping an eye on after the agreement comes into place: a provision that if either the United States or Canada makes changes in their trade laws, they can ask for a special advisory panel to determine if those changes are consistent with the GATT and the U.S.-Canada FTA. This would be a separate three-judge panel, sources say.

Despite all the legal twists and turns, many of which may not be fully understood by U.S. businessmen, there's no question that the wide-ranging trade agreement is an historic achievement. A study by Michael Aho for the Council of Foreign Relations estimates that the FTA will increase Canada's Gross National Product by as much as 7% and that it will increase U.S. GNP by about 1%. "What we've got here is a win-win agreement," Murphy told a meeting of the American League of Lobbyists.

MARTYN CHASE

Chase is a Washington, D.C.-based business writer

Will the trade pact widen Canada's electronics trade deficit with the U.S.?



Source: American Electronics Association

SEMICONDUCTORS

Why RISC chips are giving CISC a run for the money

The nifty new species of microprocessors boasts blazing speed. But their simplified design may be their undoing

By Valerie Rice

It's sleek. It's fast. It's elegant. It can leap tall calculations in a single cycle. It's RISC, and it's coming to your local semiconductor vendor some time soon.

For systems designers trying to choose the next generation microprocessor architecture, the decision process is now even more difficult. With the introduction of a slew of new RISC microprocessors in the last nine months, it's not just a choice between Intel or Motorola anymore.

In fact, when systems designers go shopping for RISC today, they have a pretty good chance of shopping from one of their competitors, like Sun Microsystems Inc., rather than their traditional suppliers. For the likes of Intel Corp. and Motorola Inc., the market dynamics have also changed. They no longer just compete against other semiconductor companies. Now they are competing with their customers.

RISC, for reduced instruction set computers, works on the "less is more" theory: 20% of a machine's instructions are activated by users 80% of the time, so the instruction process is streamlined down to just the bare minimum and the software does the rest. Traditional microprocessors, or CISC (for complex instruction set computers), contain a full instruction set and are less dependent on power software.

The essence of RISC, then, is raw speed. RISC processors are commonly two to five times faster than traditional versions; some can be 10 times speedier. For over 85 announced systems and board level companies, raw speed is enough, as they have eschewed the well-entrenched traditional processors offered by Motorola and Intel and gone maverick.

Catering to that maverick market are a number of firms including workstation maker Sun Microsystems with its SPARC architecture, Advanced Micro Devices Inc., Intergraph Corp., MIPS Computer Systems Inc., Motorola Inc. and just recently, United Technologies Corp.

RISC chips from these vendors and undoubtedly others will own 20% of the 32-bit market by 1992, according to market research firm Dataquest Inc. Another researcher, Integrated Circuit Engineering Corp. (ICE) is even more optimistic: analysts there predict that RISC will account for 35% of the market by then.

Where will these RISC chips go? According to ICE, of the 35% of the 32-bit market that RISC chips will own, 20% of them will be in workstations, 5% in office automation or PC applications, and 10% in the "other" category, comprising military and embedded control applications, among others.

"There is finally enough evidence to show, once and for all, that RISC is a superior way to build a microprocessor," claims recent devotee Steve Blank, marketing vice president of Ardent Computers Inc.

But don't sound the death knell for traditional microprocessors yet. RISC chips may have found their niche in high-end workstations and compute-intensive applications, but ownership of markets in low-end workstations, office automation and personal computers in general still be-

longs to the traditional microprocessor vendors.

Besides, RISC vendors face unique challenges. Despite recent significant design wins, analysts feel that RISC chips may not be viable commercially in the long term. Ease of design has made many companies today choose to design their own chips, rather than depend on third-party suppliers.

Why they take risks

The profile of a "RISC taker" is a company that is playing in the engineering or scientific workstation market, that is eager to differentiate itself, and, probably most importantly, is not squeamish about changing architectures.

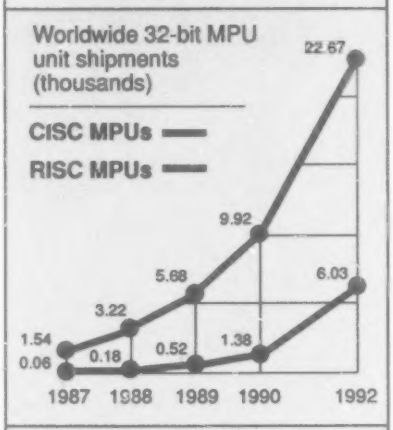
"We believe we can get a factor of two performance advantage using the RISC technology," says Forrest Basket, vice president of R&D for workstation maker Silicon Graphics Computer Systems. Of his recent decision to use the MIPS RISC architecture for his future generation of products. "You can't ignore a factor of two."

One of the downsides of RISC, Basket believes, is that the software programs have to be bigger, thus requiring more memory. "But you're buying more computing power for memory prices," he says. "That's not such a bad deal."

"The bottom line is you get the same chip, the same size and same power, but it is much, much faster," says Ardent's Blank. "And the price is certainly no more than for CISC," he adds, "It may be even less; at worst it is equal."

Blank acknowledges that writing the extra software is a hassle, but notes that "you either have to worry about building the computer, or write more software. It's worth the trade-off."

RISC will own 20% of 32-bit MPU market by 1992



Source: Dataquest Inc.

RISC chips have also come along at a time when many companies are looking for ways to further differentiate themselves from competition. Prime Computer Inc., for example, wanted to develop a workstation product for the first time, and a RISC chip seemed to offer the best performance for the high end, says Edward Vrablick, director of workstation products.

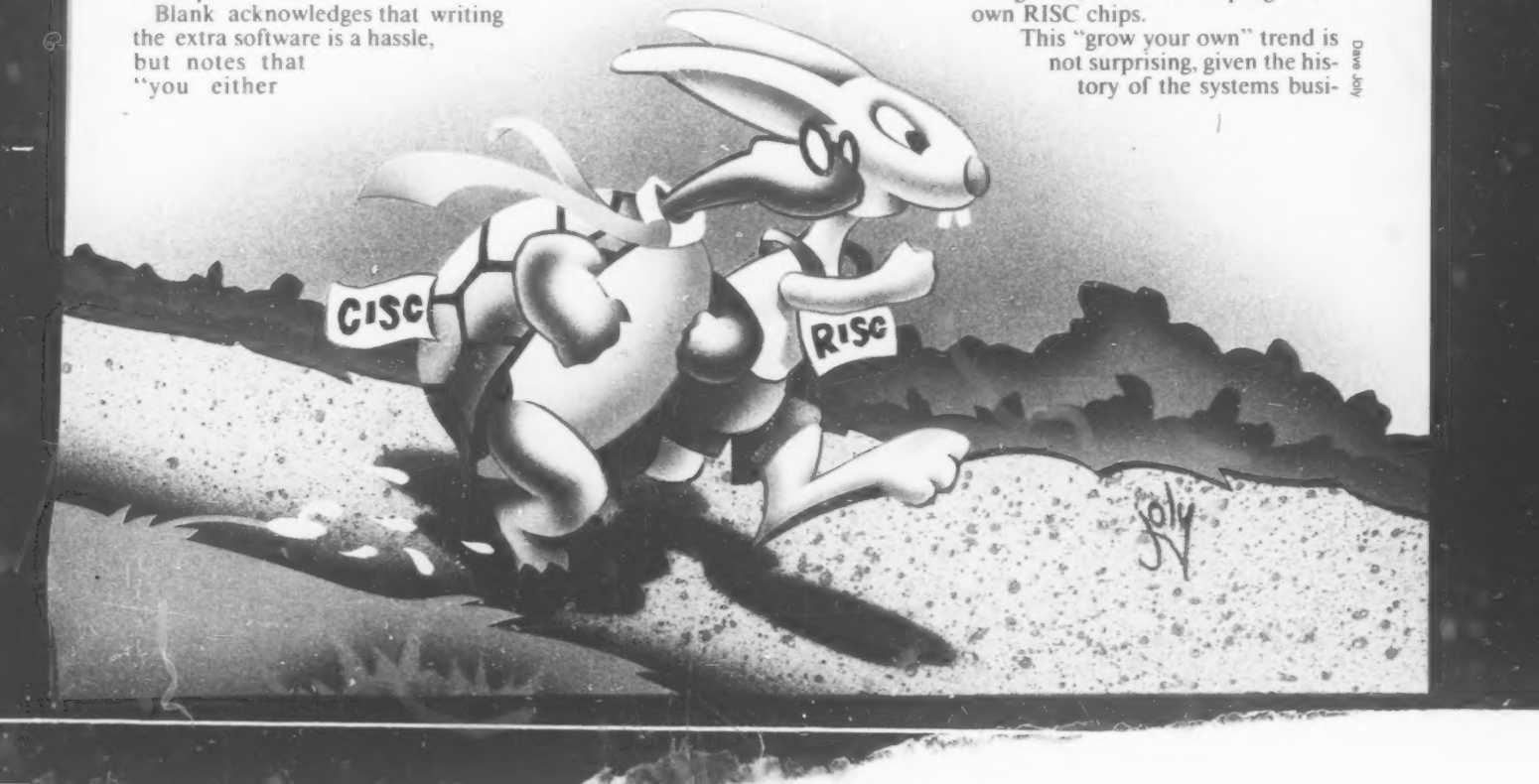
Prime's current product is a "super" workstation targeted at the high-end CAD/CAM market, Vrablick says, and the company is working on unannounced RISC products as well. Prime, which is using the MIPS architecture, says it chose MIPS because it had the most advanced compiler technology, which Prime used to overcome the largest RISC barrier — software compatibility.

Another recent convert to RISC is Xerox Corp.'s document-processing systems division. Xerox is using Sun's SPARC architecture to support its first step into the world of standard, nonproprietary platforms. Xerox wanted to choose Unix to power its document-processing systems, and the Sun offering, strengthened by its very close ties to AT&T, made the most sense, says Bruce Gitlin, Xerox's strategy implementation vice president.

As if the RISC phenomenon wasn't confusing enough, with users buying from users and suppliers competing with customers, there is another wrinkle. For every RISC design win, there are probably five that don't go to Sun, AMD or MIPS. But that is not to say that those companies aren't heavily involved in RISC. The essence of RISC — streamlining — makes the chips very easy to design, and the end result is often a homegrown one.

RISC chips are so easy to make, in fact, that many companies, including Digital Equipment Corp., Hewlett-Packard Co., IBM, Ridge Computers and others are making their own in a bid to retain a proprietary hold on their customers. Rumors abound that companies like Apollo Computer Inc., Apple Computer Inc., and Compaq Computer Corp. are following suit, and developing their own RISC chips.

This "grow your own" trend is not surprising, given the history of the systems busi-



ness, says Andrew Rappaport, president of market research firm Technology Research Group. The development of third-party microprocessors is an aberration, he declares. "Before the invention of the PC, there was no such thing as a merchant microprocessor. Everything was proprietary. With RISC, we may see the trend swinging back. . . ."

Rappaport believes that this trend toward internal development of RISC chips may make it difficult in the future for third-party RISC vendors to find much of a market. Systems companies have "hung on to third parties," Rappaport says, because the high development costs of CISC microprocessors have made that necessary. Now with "RISC simplifying the design, it is more feasible for a company to engineer its own processor. You have less of an advantage using a third-party RISC chip than a third-party CISC chip."

"Where are all these RISC people going to sell their chips?" asks Dataquest analyst Alice Leeper. "There are some serious questions about the commercial viability of this architecture."

Those RISC companies are probably not going to find much of a market at IBM. The RT PC — IBM's engineering PC — is alive and well, with substantial order backlogs, according to Andrew Heller, vice president and general manager of the Advanced Engineering Systems group within the Entry Systems Division. IBM's RISC machine has shown success in the technical market and in office automation applications, Heller says. And IBM is unlikely to look elsewhere for RISC technology.

One way that IBM may be able to retain a strong grip on the RISC market is through development of a RISC chip that can optimize PC-DOS applications. Although Heller refused to confirm whether or not IBM was in the process of developing such a system, he notes that "it is conceivable that you will see such a system in the very near future, from IBM or someone else."

HP would not be a good candidate to switch to current RISC offerings on today's market, according to Doug Spring, general manager of HP's communication systems group. The primary reason, Spring says, is that today's market offerings are optimized for workstation applications and are not broad-based enough to appeal to HP's diverse user needs, particularly at the high end.

That narrow focus is one reason that DEC has yet to release a commercial RISC offering, says Don McInnis, DEC's engineering systems group vice president. Digital has been researching RISC for more than five years, to the point of manufacturing beta test systems, he says.

But for Digital's customer base, RISC is not the solution right now. "It doesn't offer a broad range of advantages for a broad range of customers," McInnis says. "Performance is not the only issue."

The night of the living hybrid

One of the more interesting fallouts from RISC technology has been the hybridization of existing CISC microprocessors. The next generation of CISC microprocessors from Intel and Motorola is already being touted as having "more RISC functionality."

Clearly the two technologies will merge with each other in the future, creating hybrid-like products that will hopefully offer the best of both architectures. However, many users are somewhat skeptical about a company's ability to make a CISC chip RISC-like. "There's nothing RISC-like about the 80486 or the 68040," contends Ardent's Blank, referring to the next-generation CISC microprocessors being developed by Intel and Motorola, respectively. "It's a marketing definition, nothing more."

Yet "there is always a need for compatibility for DOS-based systems," Dataquest's Leeper says. "I just don't see CISC going away in favor of RISC. CISC can use whatever technology has been learned from RISC machines."

To address those needs, Intel plans to make its 486 chip more RISC-like, more streamlined, Intel group vice president David House says, but it will add those extra transistors necessary to retain software compatibility.□

The YARP syndrome: Intel and Motorola enter the fray

It seems that RISC chips are practically crawling out of the woodwork today, compared to several years ago when the idea was considered to be on the "lunatic fringe." "I call it the "YARP" syndrome," Intel's microprocessor vice president David House says, "for 'yet another RISC processor'."

House is somewhat contemptuous of the flood of recent RISC offerings. "RISC is seen as an opportunity for all the 'have nots' in the computer architecture business to gain a foothold," he adds.

Yet even House admits that RISC has its place. However, for Intel, which has an active R&D effort in RISC, that place will likely be in embedded control applications that do not affect sales of the company's bread-and-butter 80386 product family and its installed software base.

Analysts point out, however, that Intel has less to lose from RISC design wins. Technology Research Group's Andrew Rappaport says that Intel, because it has a stronghold in PC products and not in the workstation area, is largely protected from losing design wins to RISC processors. At risk, he adds, is Motorola, "since all of the recent design wins for RISC hit Motorola where it hurts — in workstations."

That's not the way Motorola sees it, however. "If my competition thinks I am losing design wins, so much the better," declares Motorola's microprocessor marketing manager Jack Browne. "I can lull them into complacency that way."

Browne remains undaunted even though Motorola has not been scoring many design wins for its new 68030 at companies like Silicon Graphics. Sales of all the 68000 product lines are still going strong, he claims, and that trend will continue because of the strength of the installed software base. Browne's trump card, certainly, must be the company's recent announcement of a RISC microprocessor.

Details about the processor are sketchy, although performance is said to be 17 MIPS. The "88000," as it is known is a "major product for the company," with an R&D budget of $20 million, Browne says, although it is in no way a replacement for the 68000 family.

And when Motorola starts shipping the 78000, Browne says, "I'm going to get my customers back."□

WORKSTATIONS

New Age marketing: Now workstations are channeling

Vendors try channeling — third-party sales channeling — as price wars force them to adopt new distribution strategies

By David Card

As the list price of an engineering workstation is slashed — seemingly weekly — bringing it closer to that of a PC, workstation makers are being forced to open new distribution channels. If they don't pry in this year, they may be locked out forever.

"With the prices of workstations tumbling and the cost of salesforces going up, economically it becomes nonsense to sell your products all direct," says Stephen Haslett, value-added channels manager for Hewlett-Packard Co.'s Technical Systems Sector, where HP's workstations originate. An entry-level machine from any of the major suppliers, which two or three years ago cost $40,000, these days sells for under $5,000. "Long gone are the days when all you needed was a red-hot salesforce," Haslett sighs.

Once, workstations sold exclusively into the computer-aided design and engineering market. Now they are branching out into publishing, manufacturing and even office automation — applications long the turf of value-added resellers. And a new wave of personal computers is usurping workstation characteristics like tight networking, high-resolution graphics, powerful operating systems (usually Unix) and 32-bit central processors (usually Motorola Inc.'s 68000 series). PCs powered by Intel Corp.'s 80386, a 32-bit chip, can run variants of Unix and the IBM/Microsoft Corp. OS/2.

Thomas Kucharvsky, president of Boston market research firm Summit Strategies, says that historically, 60% of workstation sales are direct, compared to only 15% of PC sales. Workstation makers have to hurry to get into the cheaper third-party channels. "Especially with the way '386s are coming on," Kucharvsky says. "There's such an incredible demand for them." He adds that the PC companies "already have channels established. Workstation vendors have to start from scratch developing them." Besides VARs, there are distributors and even retail outlets to court.

Market research firm International Data Corp. of Framingham, Mass., estimates that the 7-year-old workstation market reached $2.47 billion in 1987 world sales by U.S. suppliers. This year the total will climb to $2.88 billion, but $475 million of that will go to '386-based machines and the Macintosh II PC from Apple Computer Inc., which uses the 32-bit Motorola chip. IDC also expects workstation leader Sun Microsystems Inc. to do well with its '386 machine.

Sun and the other workstation makers, including Apollo Computer Inc., Digital Equipment Corp. and HP, have gotten off to a "relatively slow start" in the VAR channel, according to IDC analyst Stephen Bosley. Even DEC and HP, which do just fine in the third-party business with their minicomputers, have yet to see more than 10% of their workstations go through VARs and distributors, adds Summit's Kucharvsky. And he estimates that companies with fewer than 500 employees will buy half of the 32-bit engineering and publishing hardware in the next five years. Those small, tough to reach companies already buy 70% of all PC-based CAD.

IDC's Bosley says the workstation

HP's HASLETT: Long gone are the days when all you needed was a red-hot salesforce"

Liane Enkelis

companies have to help VARs develop custom software. "Otherwise, everybody gets caught in the commodity game — the MIPS [millions of instructions per second] battle," he says. "Everybody loses in that. Sun has traditionally done better at that than the others, but sooner or later, even they will lose their shirt."

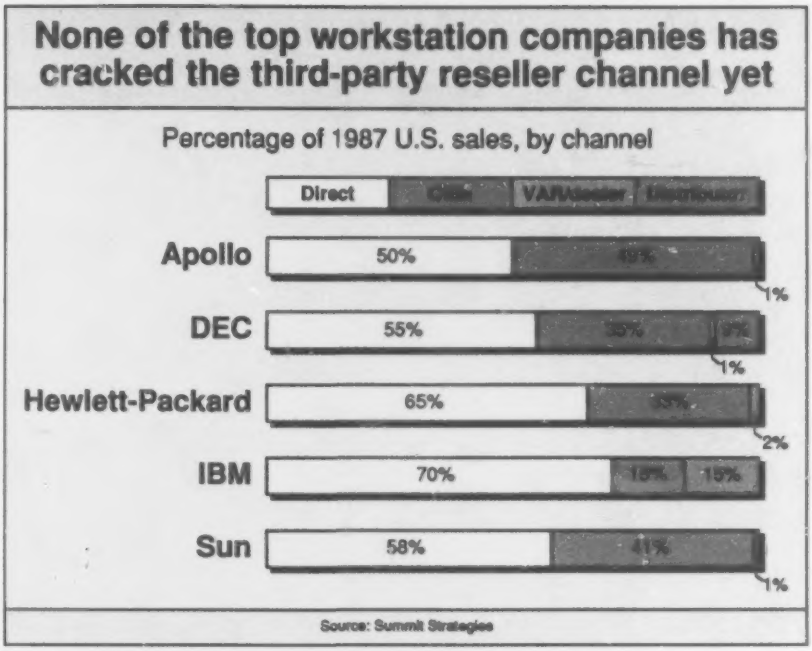
Sun has no intention of losing its shirt. Vying to retain its reputation as the hottest computer kid on the block, and eager to continue its torrid 150% yearly growth pace, Sun is launching a cross-country road show this month to spread its gospel to VARs. "We did the standard VAR mailing, about 5,000," says Sun sales vice president Joseph Roebuck, out of Mountain View, Calif. He admits to feeling some pricing pressure, but says the main reason for VAR-wooing is to help out smaller software companies that have no access to third-party channels.

Roebuck says Sun's VAR program got under way last year but sales so far "are not worth talking about." Mechanical and electronic CAD, architecture and publishing are Sun's first target markets — nothing overtly commercial yet. Roebuck would be happy to sign up 100 VARs from the trip and "ecstatic" to get a couple hundred. He doesn't see any reason to make a cutoff mark. "Limits are self-limiting," he says with the bravado characteristic of his company.

Personal CAD Systems Inc., a seller of PC software for the design of circuit boards, switched from direct sales to VARs, after a brief flirtation with manufacturers' reps. Business has been booming since, says PCAD president Douglas Stone. His marketing vice president, Michael Lack, says that he found that only 60 or 70 VARs could really handle PCAD software. Those generally also carry packages in the markets Sun is interested in, and Lack thinks a few will go with workstations as well. But not many. "An even smaller number are capable of supporting workstations," Lack claims. Of course, PCAD software competes with any number of circuit board design systems incorporating Sun hardware. But IBM and Apple are thinning their dealer ranks, qualifying fewer dealers to carry their 32-bit PCs.

Sun's arch rival Apollo of Chelmsford, Mass., started its third-party program nearly a year earlier than Sun — in December 1986 —but was more low-key about it. Apollo was also interested in software. "We got requests from some of our larger accounts," specifically Boeing Co., says Apollo's director for market development, William Kelly. "They wanted software on workstations instead of PCs," specifically, AutoCAD, the ubiquitous drafting package from Autodesk Inc. "It was just another mechanism to get software on our platform," Kelly says, "so we went with the wiles of the dealers." In terms of getting software, the program was successful. It was less so in terms of getting sales, Kelly says.

None of the top workstation companies has cracked the third-party reseller channel yet



Historically, 60% of workstation sales are direct, compared to only 15% of PC sales

Discounting prices

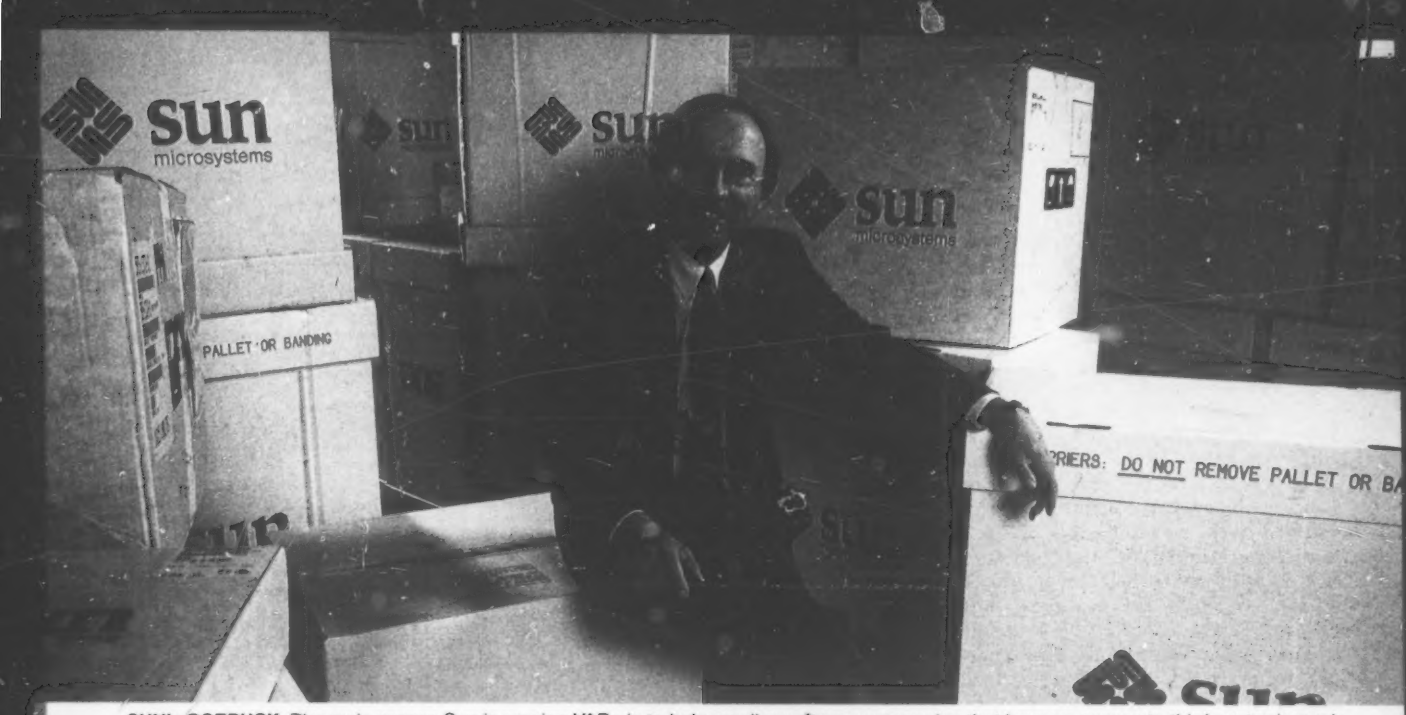
Apollo went with a finder's fee system. Leads from dealers went back to Apollo, which actually took the purchase order and handled the shipping, support and so forth. Nobody will talk specifics about their discount structures, but most VARs and dealers are used to discounts of up to 40% for volume sales. Apollo paid a 20% finder's fee, according to Kucharvsky at market researcher Summit. Kelly says Apollo is now examining a system similar to its original equipment manufacturer (OEM) discount schedule, which has more generous discounts.

Gordon Medlock, president of National CADD-Pro Inc., says it will take discounts of 40% to 50% before he will make a major commitment. National CADD-Pro is a consortium of six big regional dealers that are merging into a single operating entity to enable volume purchasing agreements. Together, the dealers would have sales of over $20 million, Medlock claims, and probably be headquartered where Medlock's region is centered, in Syracuse, Ind.

The member organizations already carry Apollo and Sun, as well as PCs from Compaq Computer Corp., IBM, Intel and NEC Corp. Medlock is a PCAD VAR, and sells mechanical CAD and manufacturing software on the workstations. Sun gives better discounts than Apollo, Medlock says, and as for DEC, "Well, we're talking to 'em." He adds: "Sun is the most aggressive and enlightened in marketing. They understand what dealers need in the way of support and discounts." He likes NEC's efforts, too.

Medlock has no problem with supporting a variety of hardware: "In terms of price and performance, anybody that's got the numbers gets invited to the party." This view is the polar opposite of at least one major industrial distributor. Wyle Laboratories carries DEC hardware, including its workstations, as well as Wyse Technology's '386 PC and a multiuser system from Convergent Technologies Inc. "Apollo, Sun; my gosh, how could we even remember enough product knowledge to keep up?" laments Wyle's vice president of computer products, Jim Hunt.

Wyle carries Tektronix Inc. graphics terminals to plug into DEC minis, but Hunt is not interested in Tek's



SUN's ROEBUCK: The main reason Sun is wooing VARs is to help smaller software companies that have no access to third-party channels

new workstation. Besides, Tek's workstation people have not called on Wyle. "We wouldn't be a good candidate," Hunt says, because he wouldn't want to upset DEC.

But National CADD-Pro glories in multiple suppliers, even in managing different operating systems, which is usually a support nightmare. "At the present time, there appears to be a DOS/Unix dichotomy," Medlock says, referring to the dominant operating systems for PCs and workstations, respectively. "The two never meet, but they have to communicate with each other. That's our business."

Integrated Graphics Systems Inc. is a Denver VAR that has not yet moved upscale from PCs to workstations. But president Steven Bruny says he advises Hitachi Ltd., whose CAD software he resells on a variety of PCs, to keep options open. "We advise them to make all future developments Unix-based as well, so when the U.S. turns to Unix, we'll be ready."

Conflicting channels

Besides discounting, there are other things the workstation companies are doing to encourage indirect marketing channels. HP's newest graphics subsystem for its workstations "was designed with a lot of input from software developers and VARs," Haslett claims. "The result was almost mundane" by HP perfomance standards, he says, but that's what the not-so-silent majority wanted. HP has a high-performance graphics workstation, the 850, to keep the power users happy.

HP is in a rather prickly position. It has hundreds of VARs for its peripherals division and a lesser number for its commercial minis and "Vectra" PCs. But the company has not exploited them for its workstations. "The reason we haven't," says Haslett, "is that we're being very cautious. The opportunity for channel conflict is enormous." HP doesn't want too many of its resellers competing with each other, let alone have them fighting off HP salespeople.

"The key is for vendors to compensate their direct salesforces for VAR sales," says analyst Bosley. "It comes down to money." All of the workstation makers have some kind of commission program. HP goes one better. PCs sold for technical applications show up on Technical Sector scorecards, even though the PCs are made by HP's commercial division. The whole situation is a little self-balancing, Haslett says. A salesman "is not going to spend a lot of time selling one Vectra when he can sell a $100,000 Model 850," he says.

Workstation makers have to hurry to get into the cheaper third-party sales channels

One of Sun's tactics to keep conflicts to a minimum is a tight set of geographical boundaries for its VARs. "It's a very, very strict value-added program," Roebuck says. "We're going to control what is sold." For instance, Sun will allow only two or three VARs, four at most, Roebuck says, in the San Francisco Bay area, each with a different application focus. HP's Haslett feels that a program like that would be restrictive: "Certainly, the VARs we work with would not be comfortable in that situation."

Kelly of Apollo sees more trouble for Sun, once its '386-based model reaches the streets. "They're going to run into horrendous channel conflicts because they'll have competing products," he warns. Treading warily was one reason behind Apollo's original finder's fee set-up, Kelly says.

In PCs, Apple reserves 70 or so key accounts for its direct salesforce, allowing its retailers a shot at every other company. Kelly says Apollo might "look at something in that vicinity." But Sun's Roebuck maintains that the Apple strategy is not for him. "We've got to make sure our own sales channel does not compete with the VARs," he says. "Every company is available to our VARs."

Analyst Kucharvsky thinks it will be an "uphill battle" for the workstation-only makers to crack the third-party market. He's more positive on the broad-range computer companies. Workstations do have in their favor the widespread price slashing of PCs on the street, Kucharvsky says. So far, end users are seeing less price fluctuation: although the workstation makers themselves are locked in list price wars, their resellers' profit margins are reasonably intact. Also on the workstation makers' side is their applications and customer base — what Kucharvsky calls "a big carrot." Most resellers haven't sold engineering systems to aerospace giants like Boeing. □

Lane Erickson

COMPONENTS

Express mail for electrons: The new wave in interconnect

The search for higher interconnect speeds is leading to more use of fiber optics and development of high-density connectors

By Michael Leibowitz

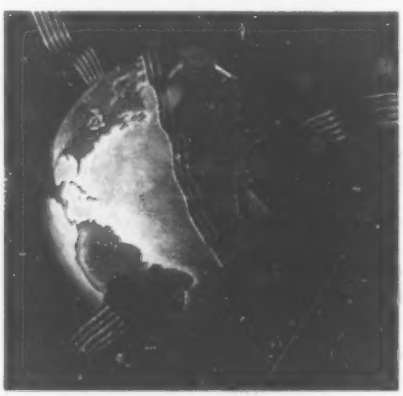
In their efforts to tap the full performance of today's semiconductors, systems builders are becoming more reliant on interconnect technologies to help speed the electrons from chip to chip. In a previous issue of ELECTRONIC BUSINESS, developments in surface mount technology, chip packaging and materials were explored. But two other areas promise faster connection of electrical signals: the new high-density connectors and fiber-optics data links.

The big trends in connectors are toward the use of fewer but more sophisticated connectors. "The connector is generally being pushed out from the middle of the system," says Nicholas Pearne, president of market research firm BPA Ltd., "as more of the heartland of the system is done on silicon or on high-density substrates."

That does not mean that the connector business is fading away. The U.S. connector business garnered a respectable 11.5% growth in 1987, reaching $5.2 billion, according to another market research organization, Fleck Telesis. While growth rates are unlikely to return to the 20% to 30% figures of the 1970s, Fleck expects a modest growth averaging 5.5% a year over the next five years. This growth will be driven, in large part, by increases in the number of electronic products being produced.

According to Kenneth Fleck, president of the Huntington Beach, Calif., market research firm, DIN connectors have registered the fastest growth of any connector product line during the past four years, racking up $50 million of sales in 1987. He expects the DIN's popularity as a reliable, sturdy 2-piece backplane connector to continue, garnering an additional 14.1% in market value each year. With 47 suppliers selling DINs into the U.S. marketplace, "price competition has been very severe," says Fleck. Prices have fallen 50% in the last four years and DINs are currently selling at as little as 1 cent per position.

Today's fastest growing connectors feature pin-counts of 100 pins and up, with the newest designs squeezing these pins into .050-inch center-to-center spacing and below. This is in contrast to the under 100-pin, .100-inch spacing connector of yesterday. Fleck estimates that the market for high pin-count connectors will grow from $62 million in 1987 at a rate of 25.4% per year. High-density connectors (with pin spacing of under .100-inch) will mushroom at the rate of 51% per year, from $37 million in 1987. Prime users will be in the high-performance computer and telecommunications industries.



Today's fastest growing connectors feature pin counts of 100 pins and up

At least 25 major suppliers sell high pin-count or high-density connectors into the U.S. market, according to Fleck. Forget about standards for awhile, however. Besides the ploy by some makers of extending the standard, 96-pin DIN connector to 150 or more pins, manufacturers have gone off in their own proprietary directions. Second sources for many of these new connectors are nonexistent.

Packing in the pins

AMP Inc.'s AMP-HDI connector is a good example of the state of the art. The 2-piece connector family packs as many as 684 pins in four rows on .100-inch spacing and is used in connecting daughter boards to a backplane or motherboard. According to Frank Pertschi, AMP's marketing director for new business development, key customers for these connectors are high-performance computer makers. A new version, called HDI-50, has recently been introduced and packs its pins on .050-inch centers, to consume half as much space.

Burndy Corp. of Norwalk, Conn., has avoided the problem of high insertion and extraction forces by designing its Ziflex card-edge connector family with a cam that is used to bring the contacts into place when the board is mated. The zero-insertion force Ziflex features from 60 to 300 contacts on .050-inch center spacing and boasts a unique surface-mounted design: No soldering is required; the connector is screwed into place and sharp, high-pressure points establish electrical contact with the solder pads of the printed circuit board.

Burndy's work in card-edge connectors revives the controversy over whether or not card-edge technology (in which the "male" portion of the connector consists of etched and plated "fingers" along the edge of the printed circuit board) is suitable for high pin-count, high-speed connections. Critics of card-edge abound,

Martin Dooley

and say that card-edge provides a less reliable, electrically dirty and mechanically inferior connection than 2-piece connectors (in which the "male" portion is a molded piece containing pins that interlock with the "female" receptacle). Such critics point to the worldwide popularity of the 2-piece DIN connector as proof that the market views 2-piece connectors as the wave of the future.

But proponents argue that a properly designed card-edge connector offers advantages over 2-piece connectors, such as electrical balance, low cost and mechanical simplicity. Card-edge connectors avoid tiny pins on .050-inch centers that can be easily damaged. Proponents also point out that IBM chose to use a Burndy card-edge design for its Micro Channel Bus in the PS/2.

"IBM has breathed new life into card-edge and the whole industry recognizes that," says Fleck. But still, continues Fleck, the overall card-edge market is in a "mature product phase." Although some special card-edge types may be moderately successful, including new high pin-count and surface-mount designs, the $340 million card-edge market as a whole will register a minimal 2.2% annual growth over the next five years.

Fiber optics are faster

Lift your eyes out of the cramped quarters of advanced electronic gear and increasingly, you will see fiber optics being used to interconnect equipment in offices, oil fields and across oceans. While datacommunications applications represent a $171 million portion of the $700 million fiber-optics market (with the major share eaten up by telephone applications), the segment is expected to burgeon to $813 million in 1992, according to Kessler Marketing Intelligence (KMI), a market research firm based in Newport, R.I.

Speed, of course, is the big advantage of fiber over alternatives such as twisted pair and coaxial cable, and KMI projects that speed-intensive applications, such as point-to-point computer interconnections and local area networks, will lead fiber-optic's datacommunications growth over the next five years. The firm says the fiber-optics market for point-to-point computer applications will grow an average of 19%, while fiber-optic use by LAN makers will skyrocket an average of 75% per year in the same period.

But John M. Kessler, KMI's president, points out that fiber optics has other advantages as well, so he expects to see other applications represent 45% of the 1992 fiber-optic market. Fiber optics is a natural in industrial environments for factory automation, where electromagnetic energy from motors and other sources can cause interference on cable lines. It eliminates any chance of sparking, a definite plus in flammable environments such as refineries. And it is difficult to tap, a consideration wherever security is important, as, for example, in foreign embassies.

But the immediate question facing the fiber-optics business is not what the market will look like five years out. "The real question," says William Hackett, AT&T's manager for product marketing for light-wave components, "is when is it really going to ramp up? It's going to be big. The question is when."

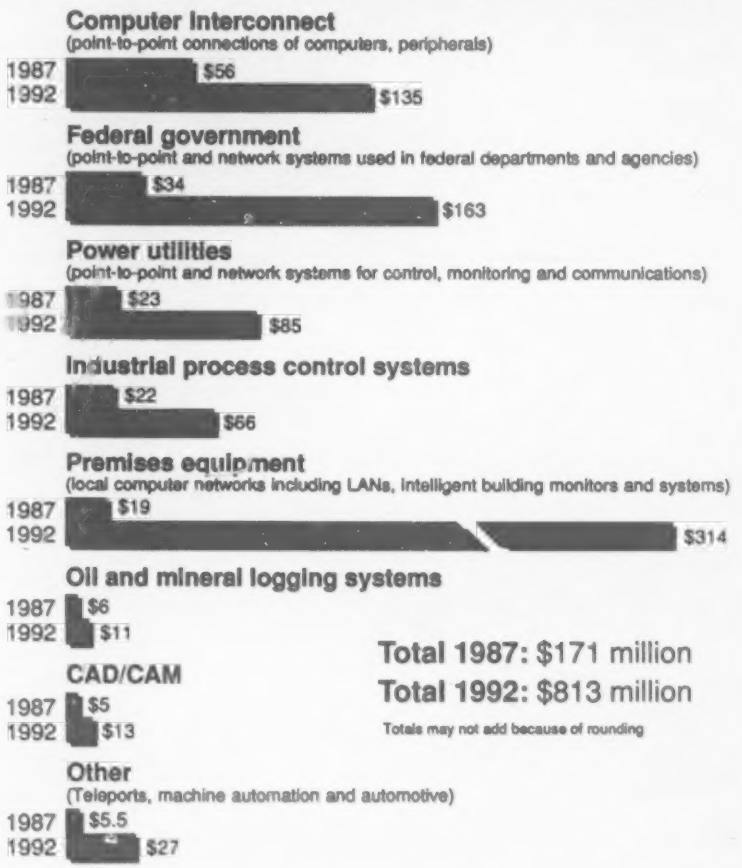
According to Hackett, near-term questions include customer acceptance, or whether end customers will decide that the advantages of fiber optics are worth its cost premium. Another barrier is lack of standards, while the main standard, the 100 megabit-per-second Fiber Distributed Data Interface (FDDI) remains unresolved by an American National Standards Institute committee. Hackett also says that equipment makers' varying level of comfort — with unfamiliar fiber-optic cable, connectors and apparatus — will be a determining factor in the short-term market.

Hackett acknowledges the difficulties of the datacommunications segment and admits that the market's performance over the next few years is unclear: "It's an emerging market. And I would be suprised if anyone's making money in that particular market."

But, he says, the datacommunications fiber market is going to be big. "We hope to see some big business in the early 1990s in both computer interconnnect and local area networks." □

U.S. consumption of fiber-optic products

Includes connectors, cable and receivers/transmitters ($ millions)



Source: Kessler Marketing Intelligence

Computer makers change the fabric of their software strategies

A look at how the top four U.S. computer makers are fitting software into their future

By Mary Jo Foley

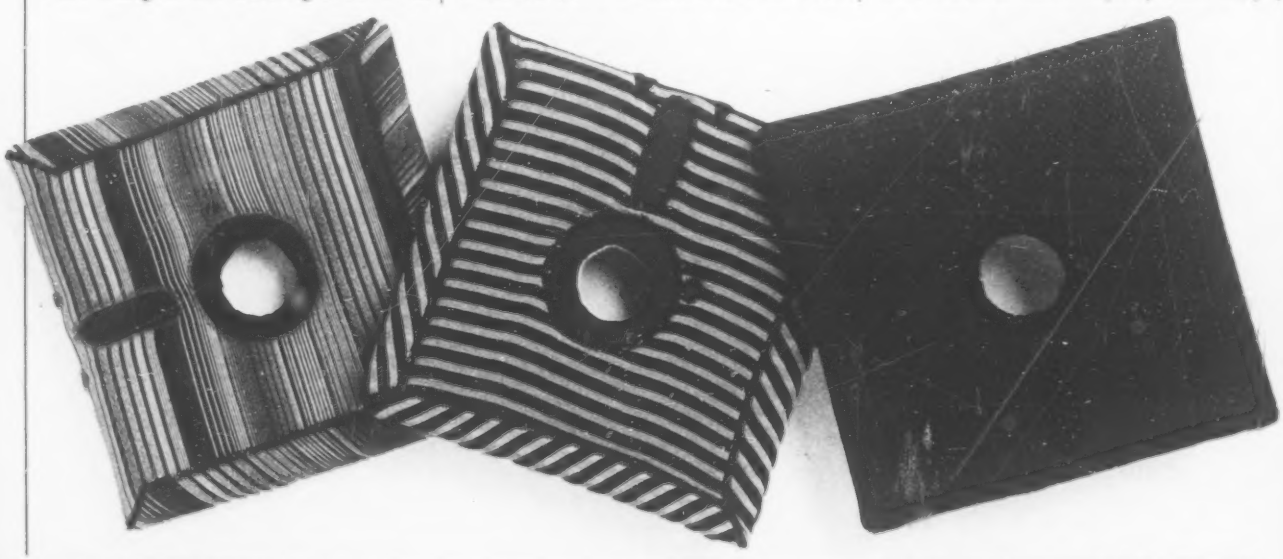
In the early 1980s, IBM predicted that in the next decade, one-third of the company's revenue would come from software. That prediction may still prove accurate, but gone are the days when any hardware maker will attempt to draw such distinctions. In fact, except for accounting purposes, few, if any, computer vendors calculate software and hardware revenue separately. The focus these days is on meeting the customer's needs, through the provision of hardware, software, or both, they claim.

This kind of slick yet subtle software rhetoric is a must for today's computer vendors. In a world where hardware margins are continuing their downward descent, while software margins are holding their own, hardware vendors cannot afford to ignore software as a key source of revenue. Besides, software is an emerging point of differentiation among hardware vendors, as well as between computer companies and the brash, younger — and many times, cash-rich — independent software vendors, or ISVs.

The results of this increasing emphasis on software already are apparent. In 1986, IBM garnered $5.5 billion, or 11.1% of its total data-processing related revenue, from software sales, according to estimates prepared by *Datamation* magazine. Unisys Corp. derived $861 million of its total DP dollars from 1986 software sales. Digital Equipment Corp. racked up $560 million in software revenue, and Hewlett-Packard Co. amassed $375 million from its 1986 software sales. These figures include operating systems, tools and utilities, and applications — packaged and turnkey. And market research firm International Data Corp. predicts that the top computer vendors' software revenue will skyrocket 20% to 30% per year until at least the end of the decade.

While these figures are impressive, U.S. computer vendors cannot afford to rest on their laurels. For, with the additional exception of Wang Laboratories Inc. (which derived $200 million from software in 1986, according to *Datamation* estimates), the rest of the top 15 DP companies in software are either foreign-based computer makers or ISVs.

Part of the reason U.S. computer vendors have not increased their software revenue more rapidly than they



Margaret Cusack

Top software vendors have a hardware look

Software revenue of top data-processing companies[1]	1986 software revenue ($ millions)	Software revenue as a percentage of total DP revenue
IBM	$5,514.0	11.1%
Unisys	$861.0	9.1%
DEC	$560.0	6.7%
NEC	$507.1	8.0%
Fujitsu	$389.2	5.9%
Siemens	$387.1	8.8%
Hewlett-Packard	$375.0	8.3%
Hitachi	$331.0	7.0%
Nixdorf	$299.5	14.4%
Lotus Development	$283.0	100.0%
Microsoft	$260.0	100.0%
CGE[2]	$238.1	23.2%
Computer Associates	$226.5	85.5%
Olivetti	$225.3	5.8%
Wang Labs	$200.0	7.5%

[1] Data-processing revenue includes income generated from mainframes, minis, micros, peripherals, datacommunication equipment, software, maintenance and other services

[2] Compagnie Generale d'Electricite

Source: *Datamation*

have is due to their basic corporate structure and orientation, according to Framingham, Massachusetts-based IDC analyst Peter Burris. "These companies are structured to sell hardware and understand the risks involved. Software is new. The risks are much higher. In software, you can really lay an egg," Burris says.

In addition, while these companies want and need to compete with ISVs, they also need to cooperate with them. Striking the right balance between competition and cooperation has proven to be a major stumbling block, even for IBM. This obstacle is, by far, more prominent in applications and tools than in operating systems software, almost all of which is written and supplied by hardware vendors. IBM's ongoing love/hate relationship over operating systems and applications for PCs with microcomputer software supplier Microsoft Corp. of Redmond, Wash., is one of many examples of this tension.

In the so-called integrated office arena — where all of the major computer vendors market one or more in-house developed applications (such as DEC's All-In-1 and IBM's Profs and Disoss) — the cooperative/competitive strain is especially high. And in rapidly expanding, hot new markets, such as distributed databases; networking and communications applications; desktop publishing; and other graphics applications, computer vendors are bumping into ISVs more and more regularly.

A fairly recent development which is enabling many vendors to smooth out the rough edges in their dealings with ISVs is the "spectrum" approach to third-party programs. Rather than dealing with ISVs on an ad hoc basis (as IBM admits it has tended to do in the past), or by trying to pigeonhole all third-party relationships into one or two narrow categories, all of the major computer vendors now seem to provide ISVs with a range of choices in their dealings with them. Even though each vendor has its own name for its particular programs, all seem to offer similar terms and conditions. These programs run the gamut from simple cross referencing of software, to joint marketing or development. Actual buy-outs of ISVs or their products now seems to be a thing of the past.

Besides strategic alliances, there are several other common software issues computer vendors need to address, according to Michael Cohn, an analyst with the Mountain View, Calif., market research firm, Input. These include:

- adherence to emerging industry standards;
- inter-line compatibility—a problem most vendors seem to be at-

tempting to solve via common "application environments," like IBM's Systems Applications Architecture and HP's NewWave; rather than via common operating systems, like DEC's VMS;

- intra-line compatibility, or the ability to communicate and share data in "mixed," or multiple vendor, environments;
- software integration, or the need to be able to supply in-house developed or third-party software in multiple areas: the one-stop shopping approach;
- the need to offer more than "just" software — for instance, professional services, education, training, and, increasingly, computer-systems integration skills.

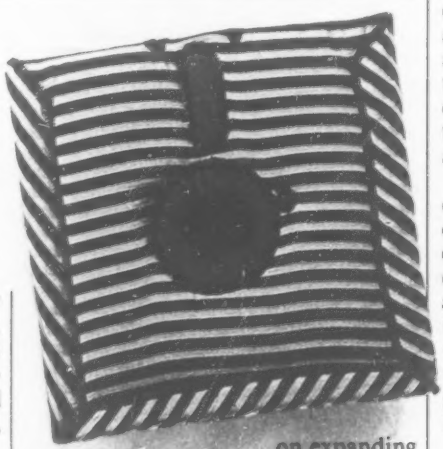
Despite these commonalities, each U.S. computer vendor is taking a fairly different path — in terms of its software organizational structure, marketing, sales and distribution strategies. Highlights of the software strategies of the top four U.S. computer vendors follow.

IBM

Application software division hits the ground running

Last year, IBM added two new acronyms to its repertoire, which sum up succinctly its emerging software directions: Application Systems Division (ASD), and Systems Application Architecture, (SAA).

ASD, headquartered in Milford, Conn., is IBM's hub for application software support worldwide. Although much of its initial activity since its formation in July has centered on beefing up IBM's midrange software offerings, ultimately it will develop and acquire applications for all IBM hardware. In order to do this, the division is concentrating heavily



on expanding its third-party software options — especially through its cooperative software program and marketing assistance program (MAP). IBM's announcement last year that Lotus Development Corp. would develop and co-market a mainframe version of its popular 1-2-3 spreadsheet is seen as only the first of many such third-party software coups to come. The National Solutions Center, a database of application packages available from IBM, currently lists about 3,500 application packages, 500 of which were developed internally by IBM.

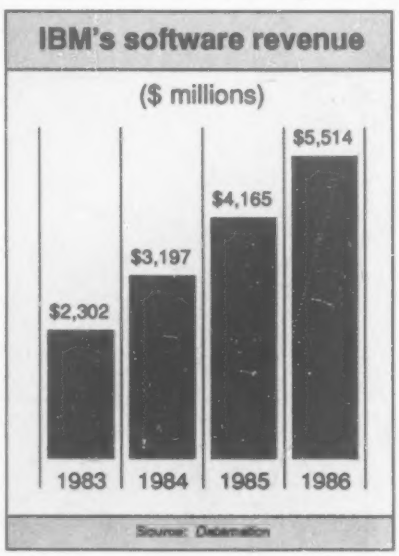
"Once we announced ASD, we were overwhelmed by letters from ISVs [independent software vendors]. In fact, we're still digging out," says Robert Berland, vice president of the vendor and development operations segment of the division. "Before July, companies didn't know how to approach us. Now there's a focal point."

ASD consists of five subdivisions: application development systems and integration; computer integrated manufacturing systems; finance and general systems; office systems; and Berland's vendor and development operations. All five are connected via SAA, which is IBM's master plan for providing a common software environment across its primarily incompatible microcomputers, minicomputers, and mainframes. Announced last spring, SAA is a collection of user interface, programming language, and communication standards. They are detailed in various technical manuals, which IBM is in the process of making available to independent software vendors and end users alike.

The application development systems and integration subdivision is charged with ensuring that all ASD and third-party software products comply with SAA. The subdivision also is responsible for most IBM tools and utilities. Berland's division — through its establishment of SAA education and support groups for the third-part community — also plays a key role in IBM's SAA strategy.

In short, "IBM is becoming more open in terms of working with the outside," Berland says. Big Blue has come to realize that "software vendors are critical to the success of IBM and its customers. When we created the division, one of its major thrusts was to energize the software community to build on IBM — even if the software may directly compete with IBM [developed] software."

This admission that even a $51 billion company may not have enough money and expertise to succumb to the "not invented here syndrome" is a new departure for IBM. The company is expected to continue to write and enhance many applications for all levels of hardware itself. But, as Berland acknowledges, "There's a trend toward the concept of seeing software as an enabler of customer solutions. Many of these solutions will come from the outside."



digital

A proprietary operating system holds its own

Digital Equipment Corp.'s marketing slogan, "Digital has it now," is a vast understatement in terms of the company's software strategy. Unlike the other major computer hardware vendors, DEC has had the "luxury" — in the words of Roger Heinen, corporate consulting engineer for software systems — of

running a single proprietary operating system, VMS, on all of its VAXs since 1978. As a result, "we don't need an SAA [IBM's Systems Application Architecture]," Heinen claims. "We're 10 years further in evolution" than the other vendors.

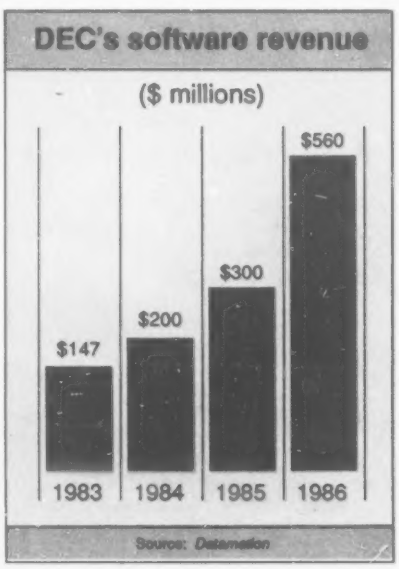
So, while other manufacturers are racing to make their lines more compatible and thus more attractive to independent software vendors and end users both, DEC's charge is to stay its tried and true course. In DEC's case, that is "to deliver complete information systems to customers based on VAX, VMS, OSI [Open Systems Interconnect], and DECNet," Heinen says, "as well as to integrate with other [companies' hardware and software] architectures."

Thanks to DEC's cross-line compatibility, market watchers say its cooperative marketing partnership (CMP) program is one of the most successful third-party software organizations in the industry. Currently, the only applications DEC develops and enhances itself are those common to all users, such as integrated office software like All-In-1.

DEC's central software organization, which employs over 2,000 people and operates primarily out of its Spit Brook development facility in Nashua, N.H., is organized vertically by applications marketing groups, and horizontally by industry marketing groups. Its application groups include office, laboratory, engineering, factory, and corporate MIS (management information systems); its industry groups include insurance, finance, banking, and such. The company's recent moves to add multiprocessing capabilities to VMS via its real-time VAXeln software package will give DEC a boost in several of these key areas, most notably factory and engineering, Heinen says.

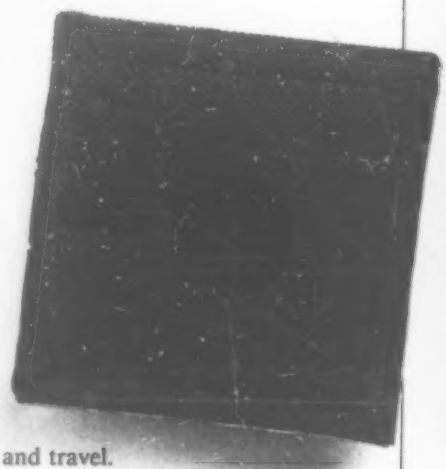
At the same time, DEC is working to establish and firm up its presence in other areas, including transaction processing, networking and desktop computing, Heinen says. It also is attempting to expand its offerings by ramping up marketing and sales of Ultrix, its Berkeley 4.2 based (but AT&T System V compatible) version of the Unix operating system. Analysts say DEC has placed undue emphasis on its proprietary VMS system at the expense of industry-standard Unix in order to lock in customers.

"We just need to have field service people ready and able to support the product," Heinen retorts. DEC has been striving to reach this point for two years; now its efforts are coming to fruition, he says. "Customers do understand the difference between VMS and Ultrix, and it's usually obvious which is the appropriate choice." With its DECWindows interface, however, users are able to run both operating systems simultaneously, he points out. In fact, "marketing the two products has been much easier than we ever imagined," Heinen claims.



UNISYS

Line-of-business focus aids in integration



It is not only incompatible Sperry and Burroughs hardware architectures that have plagued Unisys Corp. since its creation from the merger of the two companies in 1986. Equally, if not more so, the mishmash of operating systems, ranging from the proprietary 1100 OS to industry-standard Unix and MS/DOS, have proven difficult for Unisys to integrate. One factor which has worked in the company's favor from a software standpoint, however, is its line-of-business emphasis.

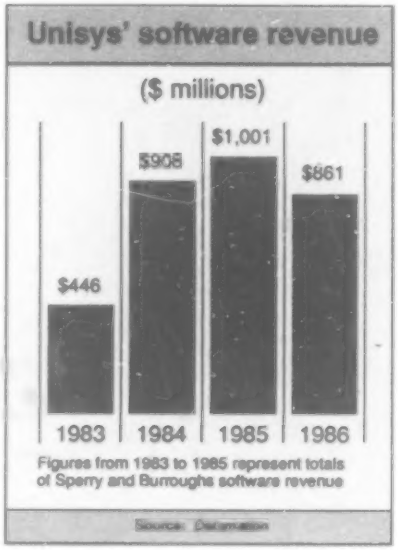
"Unisys has placed, indirectly, value on applications software by our commitment to a line-of-business focus," according to L.W. "Roy" Beers, vice president of corporate industry management for the Blue Bell, Pennsylvania-based corporate marketing services division. "This means a fully vertical commitment to providing every aspect of a solution to companies in those particular businesses." These lines of business include: commercial and industrial; finance; public sector including hospitals, schools and the like; and communications and travel.

Unisys develops and maintains the extremely complex applications software it offers in these areas. Some of its products include its Global Financial System, Police Information Management System, and Health Care Financial Management System, to name a few. "If R&D dollars spent is the measure, there's more activity at Unisys in internal [software] development," Beers acknowledges. "Many of these large sophisticated solutions are beyond the capabilties of many third parties."

"But from a number of products standpoint, the balance [between internal and third-party development] may be weighted the other way," he continues. Especially in so-called cross-industry applications — ac-

counting, for example — Unisys is relying more heavily on third parties to develop and support software for Unisys machines.

In order to make its hardware attractive to third-party software developers in an increasingly IBM/DEC-dominant world, Unisys is placing a lot of emphasis on "system independent software," in Beers' words. To a large extent, this means Unix. But it also includes the provision of sophisticated fourth-generation languages and tools — such as Unisys' Linc and Mapper development products — so that programmers can write software for one system and easily recompile it to run on another. "If you do applications development right and make software machine-independent, you don't need to worry about hardware platforms," Beers claims.



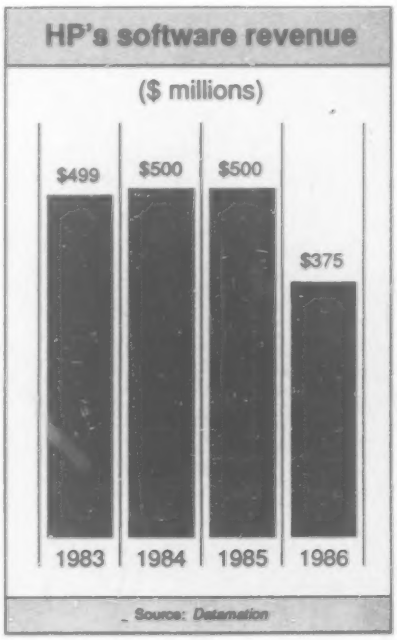
"For awhile, HP thought we could do a lot more in applications development ourselves," admits Robert Frankenberg, general manager for the business systems's Information Systems Group. "Now, the vast majority of applications come from third parties. We decided it was better to work with other companies, except in areas where we had the expertise."

"Sometimes, there is a problem in terms of our [HP-developed] offerings competing with theirs," adds William Parzybok, general manager of the engineering and manufacturing systems group. "We want it all, just like they want it all."

But, first with HP's introduction of its AT&T System V-based Unix system, known as HP-UX, and now with NewWave, HP is attempting to offer third-party developers access to more open platforms in order to increase the number and quality of applications available on HP hardware. "NewWave will provide third parties with the opportunity to substantially differentiate their applications from their competitors," claims Frankenberg.

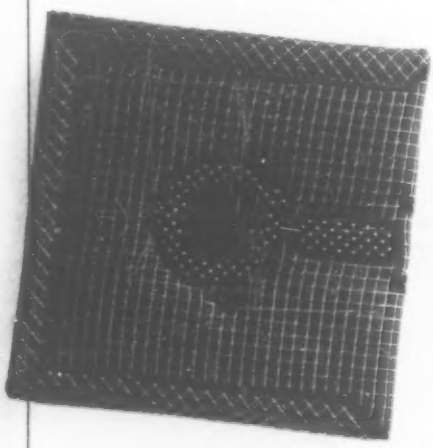
"We treat software as a technology, not a business," Frankenberg continues. "Complex user needs are now being satisfied better by software," than by hardware. NewWave and more third-party offerings will ensure that HP meets these needs, he says.

Foley is a Washington, D.C.-based business and technology writer



Riding the NewWave to compatible software environments

Hewlett-Packard Co.'s November announcement of its NewWave environment was the biggest software news to come from the Palo Alto, Calif., company in quite awhile. In the short run, NewWave may prove to be little more than a fancy marketing tool. But, as it is ported from HP's personal computers to its various technical workstations, and ultimately to HP's various minicomputers, it promises to bring cross-line compatibility equal to, if not greater than, that anticipated from IBM's Systems Application Architecture strategy.



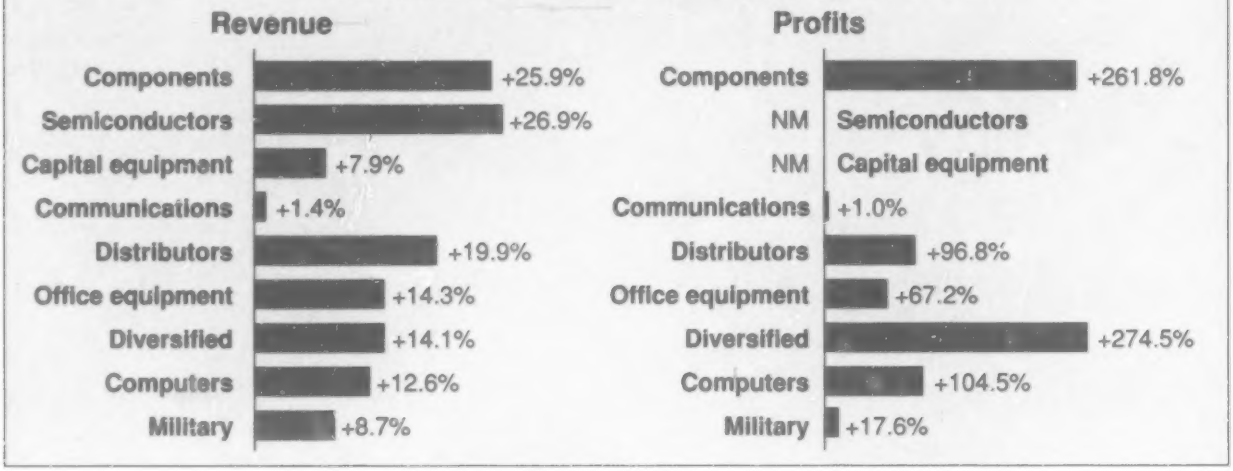
In brief, NewWave is a software-application environment, based on the emerging Microsoft Corp. Windows standard. It incorporates object-management technology, artificial intelligence principles, and a common graphics interface to allow users to access data and files seamlessly from multiple sources. NewWave is currently available to third parties, and will be shipped to end users sometime in the second half of this year.

Prior to NewWave's introduction, there was relatively little software synergy among HP's business, engineering and manufacturing systems sectors — the three HP areas responsible for developing, selling and supporting most of what is considered traditional computer hardware. The business sector is subdivided into four divisions: office and productivity; office systems; personal software; and workstations. Collectively, these concentrate on office applications such as electronic mail, document generation packages, communication software and so forth. Engineering and manufacturing, on the other hand, are more involved in supplying customized turnkey solutions in the areas of computer-aided engineering, design and manufacturing. Operating systems software for all three divisions tends to be handled by the respective hardware divisions.

Financial results of leading U.S. electronics companies

Industry segment averages

Percentage change from 4th quarter of 1986 to 4th quarter of 1987



	4th quarter figures				Year-to-date figures				
Components (other than semiconductors)	Revenue 4th quarter 1987 ($ millions)	Change from 1986	Profits 4th quarter 1987 ($ millions)	Change from 1986	Revenue year-to-date 1987 ($ millions)	Change from 1986	Profits year-to-date 1987 ($ millions)	Change from 1986	Quarter ended
AMP	$633.0	25.0%	$70.0	51.2%	$2,318.0	19.9%	$250.0	52.1%	Dec. 31
AVX	79.8	57.9%	4.6	NM	271.9	39.2%	15.8	NM	Dec. 31
Augat	80.9	25.5%	3.3	NM	313.2	20.3%	11.5	NM	Dec. 31
BRIntec	70.2	5.6%	2.1	40.2%	293.7	3.6%	5.9	-51.2%	Dec. 31
Kollmorgen	84.0	18.6%	1.1	NM	301.0	-5.7%	0.3	NM	Dec. 31
Molex	122.9	33.9%	14.3	50.6%	437.1	25.1%	50.2	29.2%	Dec. 31
Segment composite	**$1,070.80**	**25.9%**	**$95.40**	**261.8%**	**$3,934.90**	**17.8%**	**$333.70**	**81.8%**	
Semiconductors									
Advanced Micro Devices[1]	$262.5	32.8%	-$2.6	NM	$997.1	20.3%	-$48.1	NM	Dec. 31
Burr-Brown	38.5	34.6%	1.7	1,023.3%	140.5	24.6%	4.3	14.7%	Dec. 31
Intel	572.5	61.0%	95.5	NM	1,907.1	50.8%	248.1	NM	Dec. 31
LSI Logic	78.3	43.6%	5.8	237.2%	262.1	34.9%	11.3	194.2%	Dec. 31
Texas Instruments	1,534.7	14.9%	93.7	252.3%	5,594.5	12.5%	308.5	673.2%	Dec. 31
Western Digital	160.7	40.4%	8.2	-15.1%	563.1	50.8%	44.4	40.8%	Dec. 26
Segment composite	**$2,647.2**	**26.9%**	**$202.3**	**NM**	**$9,464.4**	**22.1%**	**$568.5**	**NM**	
Capital equipment									
Fluke	$51.5	0.7%	$2.9	10.4%	$206.7	-0.9%	$2.3	-80.3%	Dec. 25
GenRad	50.7	-5.4%	1.1	NM	193.8	9.4%	-37.0	NM	Jan. 2
Tektronix	318.6	-0.5%	4.8	-72.5%	1,388.9	2.7%	25.7	-53.4%	Nov. 14
Teradyne	96.1	13.0%	-11.2	NM	377.7	7.6%	-21.1	NM	Dec. 31
Varian	265.0	23.3%	-17.6	NM	1,033.0	15.6%	-4.1	NM	Jan. 1
Segment composite	**$781.9**	**7.9%**	**-$20.0**	**NM**	**$3,200.0**	**7.3%**	**-$34.3**	**NM**	
Communications									
Andrew	$54.5	11.9%	$2.7	16.9%	$229.0	15.7%	$4.2	-55.9%	Dec. 31
DSC Communications	79.6	6.8%	5.1	115.4%	312.4	2.8%	14.6	31.9%	Dec. 31
Dynatech	94.6	19.8%	6.1	-9.2%	347.0	17.3%	21.1	-15.0%	Dec. 31
General DataComm	44.2	-17.1%	-7.6	NM	192.6	1.1%	-8.2	NM	Dec. 31
Micom Systems	56.6	11.3%	1.9	10.5%	211.5	9.9%	9.3	275.7%	Dec. 31
Northern Telecom	1,300.0	0.0%	140.0	5.9%	4,900.0	11.4%	347.2	10.9%	Dec. 31
Segment composite	**$1,629.5**	**1.4%**	**$148.1**	**1.0%**	**$6,192.4**	**11.0%**	**$388.1**	**6.4%**	

[1] Includes Monolithic Memories Inc. since August 13, 1987 acquisition

NM = Not meaningful; company had a loss in the base year

(Continued)

Financial results of leading U.S. electronics companies

	4th quarter figures				Year-to-date figures				
Distributors	Revenue 4th quarter 1987 ($ millions)	Change from 1986	Profits 4th quarter 1987 ($ millions)	Change from 1986	Revenue year-to-date 1987 ($ millions)	Change from 1986	Profits year-to-date 1987 ($ millions)	Change from 1986	Quarter ended
Anthem Electronics	$56.9	39.9%	$1.9	322.1%	$196.9	48.8%	$5.0	76.0%	Dec. 31
Avnet	429.3	14.2%	12.9	180.4%	1,670.7	13.2%	37.3	94.3%	Jan. 1
Marshall Industries	101.3	52.0%	4.2	404.5%	340.3	26.4%	10.6	135.7%	Nov. 30
Pioneer-Standard	63.1	23.3%	1.3	229.6%	238.5	16.3%	4.4	385.7%	Dec. 31
Premier Industrial	127.7	11.3%	15.5	30.4%	486.8	9.7%	56.0	27.8%	Nov. 30
Segment composite	**$778.3**	**19.9%**	**$35.8**	**96.8%**	**$2,933.2**	**16.1%**	**$113.2**	**59.0%**	
Office equipment									
Diebold	$119.3	6.1%	$11.9	19.7%	$439.1	5.2%	$35.8	2.5%	Dec. 31
NCR	1,820.1	15.6%	161.4	20.4%	5,640.7	15.5%	419.3	24.6%	Dec. 31
Pitney Bowes	643.4	14.2%	67.9	26.0%	2,250.5	13.3%	199.4	20.1%	Dec. 31
Wang	784.7	17.3%	34.1	NM	3,047.6	14.2%	94.5	NM	Dec. 31
Xerox	4,200.0	13.5%	155.0	12.3%	14,900.0	15.5%	578.0	18.4%	Dec. 31
Segment composite	**$7,567.4**	**14.3%**	**$430.3**	**67.2%**	**$26,277.9**	**15.0%**	**$1,327.0**	**41.3%**	
Diversified									
General Instrument	$298.1	32.7%	$19.9	243.5%	$1,104.0	56.3%	$53.7	206.0%	Nov. 29
Gould	242.9	6.8%	8.7	58.2%	933.4	2.7%	25.0	-27.7%	Dec. 31
Harris	501.4	-6.1%	24.2	20.1%	2,223.3	6.0%	92.2	34.4%	Jan. 1
Honeywell	1,985.1	22.8%	86.1	NM	6,679.3	24.2%	253.7	1,866.7%	Dec. 31
Motorola	1,850.0	14.2%	102.0	61.9%	6,700.0	13.8%	308.0	58.8%	Dec. 31
Tandy	1,303.0	8.9%	130.8	27.8%	3,654.7	10.0%	289.0	27.9%	Dec. 31
Segment composite	**$6,180.5**	**14.1%**	**$371.6**	**274.5%**	**$21,294.8**	**16.3%**	**$1,021.6**	**84.6%**	
Computers, peripherals and software									
Amdahl	$482.9	43.4%	$53.0	79.1%	$1,505.2	55.8%	$146.0	249.0%	Dec. 25
Apollo	163.0	34.8%	10.5	99.4%	553.7	41.4%	21.7	132.5%	Dec. 31
Apple	1,042.4	57.4%	121.4	107.6%	3,041.3	49.1%	280.3	80.3%	Jan. 1
Control Data	927.5	2.6%	17.5	NM	3,366.5	0.6%	25.0	NM	Dec. 31
Compaq	432.1	131.2%	49.0	201.8%	1,224.1	95.8%	136.3	217.7%	Dec. 31
Cray Research	163.6	18.4%	34.1	46.1%	687.3	15.2%	147.1	17.4%	Dec. 31
Data General	342.9	9.4%	12.4	275.8%	1,304.0	1.3%	-73.7	NM	Dec. 26
Digital Equipment	2,782.3	22.5%	329.5	22.1%	10,391.1	23.5%	1,284.3	49.1%	Dec. 31
Genicom	87.7	103.4%	3.3	31.9%	302.2	91.9%	10.5	22.4%	Dec. 31
IBM	18,011.0	6.3%	2,087.0	50.1%	54,217.0	5.8%	5,258.0	9.8%	Dec. 31
Intergraph	195.3	24.1%	24.7	26.7%	641.1	5.8%	69.9	-0.7%	Dec. 31
Lotus Development	115.6	41.3%	22.9	46.8%	395.6	39.8%	72.0	49.1%	Dec. 31
Mentor Graphics	61.4	24.5%	6.1	55.9%	221.8	27.8%	20.3	84.8%	Dec. 31
Micropolis	80.4	55.2%	7.2	39.7%	288.3	35.2%	27.2	49.3%	Dec. 25
Microsoft	155.9	92.5%	35.3	79.4%	456.7	75.5%	92.9	61.2%	Dec. 31
Miniscribe	116.2	119.7%	9.1	42.3%	362.5	96.1%	31.1	37.1%	Dec. 31
Prime	227.0	-5.4%	21.3	50.5%	960.9	11.7%	64.8	38.0%	Dec. 31
Seagate Technology	332.5	32.0%	22.8	-39.3%	1,075.7	51.6%	115.3	27.6%	Dec. 31
Storage Technology	208.2	13.0%	5.6	134.3%	750.0	7.8%	19.0	12.8%	Dec. 25
Stratus Computer	55.2	56.0%	6.5	77.0%	184.2	47.8%	19.4	43.5%	Jan. 3
Sun Microsystems	235.1	101.8%	14.0	64.1%	754.4	120.1%	48.0	99.1%	Dec. 25
Unisys	2,798.9	10.4%	216.9	NM	9,712.9	30.7%	578.0	NM	Dec. 31
Segment composite	**$29,017.1**	**12.6%**	**$3,110.2**	**104.5%**	**$92,396.2**	**14.1%**	**$8,393.4**	**36.5%**	
Military									
E-Systems	$315.6	4.8%	$17.7	19.0%	$1,227.2	8.1%	$60.4	-1.9%	Dec. 31
GM Hughes	2,700.0	3.8%	146.0	36.4%	10,500.0	1.0%	670.0	12.8%	Dec. 31
Logicon	56.7	15.4%	2.5	11.6%	211.5	3.4%	6.6	-29.6%	Dec. 31
Loral[1]	373.6	126.2%	18.7	40.0%	1,028.3	116.4%	51.7	30.6%	Dec. 31
Raytheon	2,137.0	4.7%	117.9	18.4%	7,659.0	4.8%	445.1	13.2%	Dec. 31
Singer	563.4	13.7%	10.6	-64.7%	1,902.7	10.3%	23.4	-60.0%	Dec. 31
Watkins-Johnson	69.6	7.9%	4.9	36.2%	264.3	3.5%	17.8	3.2%	Dec. 31
Segment composite	**$6,215.9**	**8.7%**	**$318.3**	**17.6%**	**$22,793.0**	**6.0%**	**$1,274.9**	**8.7%**	

[1] 1987 results include the results of Goodyear Aerospace Corp. (acquired on March 13, 1987) now called Loral Systems Group

NM = Not meaningful: company had a loss in the base year